

Contractor's Report to the Board

Landfill Facility Compliance Study Phase I Report— Results of Screening Analyses of 224 California MSW Landfills

December 2003

Produced under contract by:

***GeoSyntec Consultants, Inc.
Walnut Creek, California***



Zero Waste—You Make It Happen!

STATE OF CALIFORNIA

Gray Davis
Governor

Winston H. Hickox
Secretary, California Environmental Protection Agency

•
INTEGRATED WASTE MANAGEMENT BOARD
•

Mark Leary
Executive Director

For additional copies of this publication, contact:

Integrated Waste Management Board
Public Affairs Office, Publications Clearinghouse (MS-6)
1001 I Street
P.O. Box 4025
Sacramento, CA 95812-4025
www.ciwmb.ca.gov/Publications/
1-800-CA-WASTE (California only) or (916) 341-6306

Publication #520-03-006



Printed on recycled paper containing a minimum of 30 percent postconsumer fiber.

Copyright © 2003 by the California Integrated Waste Management Board. All rights reserved. This publication, or parts thereof, may not be reproduced in any form without permission.

Prepared as part of contract no. IWM-C9047 (total contract amount: \$654,063, includes other services).

The California Integrated Waste Management Board (CIWMB) does not discriminate on the basis of disability in access to its programs. CIWMB publications are available in accessible formats upon request by calling the Public Affairs Office at (916) 341-6300. Persons with hearing impairments can reach the CIWMB through the California Relay Service, 1-800-735-2929.

The energy challenge facing California is real.

*Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, **Flex Your Power** and visit www.consumerenergycenter.org/flex/index.html.*

Disclaimer: This report to the Board was produced under contract by GeoSyntec Consultants, Inc. The statements and conclusions contained in this report are those of the contractor and not necessarily those of the California Integrated Waste Management Board, its employees, or the State of California and should not be cited or quoted as official Board policy or direction.

The State makes no warranty, expressed or implied, and assumes no liability for the information contained in the succeeding text. Any mention of commercial products or processes shall not be construed as an endorsement of such products or processes.

Table of Contents

Acknowledgments.....	iii
Executive Summary	1
1 Introduction	2
1.1 Background Data Collection	2
1.2 Report Organization	4
2 MSW Landfill Site Characteristics Used in Analyses.....	5
2.1 Introduction	5
2.2 Landfill Site Characteristics	5
3 Methodology for Environmental Performance Screening Analyses	23
3.1 Introduction	23
3.2 Statistical Analysis Approach	23
3.3 Indicators of Environmental Performance.....	24
4 Results of Environmental Performance Analyses by Individual Landfill Site Characteristics	32
4.1 Owner Type.....	32
4.2 Landfill Age	34
4.3 Landfill Size (Permitted Disposal Area)	36
4.4 Social Setting.....	39
4.5 Physical Setting	40
4.6 Underlying Geologic Material.....	43
4.7 Minimum Depth to Underlying Groundwater.....	44
4.8 Average Annual Precipitation	46
4.9 Liner Type	48
4.10 Final Cover Type.....	50
4.11 Landfill Gas Collection System.....	51
4.12 Site Status.....	53
4.13 Fill Method.....	54
5 Results of Multiple-Variable Analyses	56
5.1 “Typical” California MSW Landfill.....	56
5.2 Summary and Comparison of Urban, Suburban, and Rural Landfills.....	57
5.2.1 Brief Overview of Urban, Suburban, and Rural Landfills By Eight Landfill Site Characteristics	57
5.3 Summary of Environmental Performance of Active, Inactive, Closed, and Combination Landfills by Five Landfill Site Characteristics.....	64
6 Conclusions	71
6.1 Key Findings of Landfill Site Characteristics	71
6.2 Key Findings of Environmental Performance Analyses By Landfill Site Characteristics	72
6.3 Key Findings Based on Non-Quantified Observations	73

7	Recommendation of 40 MSW Landfills for Phase II of Study	74
7.1	Introduction	74
7.2	Forty Landfills Recommended for Further Study	74
	Appendix A: A Brief Overview of Non-MSW Landfills.....	A-1
A.1	Introduction	A-1
A.2	Non-MSW Waste Disposal Sites	A-1
A.3	Waste Types	A-1
	Appendix B-1: Statistical Analysis Processes Used in Study and General Explanations.....	B-1-1
B-1.1	Evaluation of Categorical Independent Variables	B-1-1
B-1.2	Logistic Regression Analysis of Categorical Independent Variables.....	B-1-2
B-1.3	Evaluation of Continuous Independent Variables	B-1-5
	Appendix B-2: Assessment of Individual MSW Landfill Site Characteristics By Gas Enforcement Action Status	B-2-1
	Appendix B-3: Assessment of Individual MSW Landfill Site Characteristics By Gas Inspection Report Status	B-3-1
	Appendix B-4: Assessment of Individual MSW Landfill Site Characteristics By Corrective Action Status	B-4-1
	Appendix B-5: Assessment of Individual MSW Landfill Site Characteristics By Surface Water Action.....	B-5-1
	Appendix C-1: Analysis of Independence—Owner Type	C-1-1
	Appendix C-2: Analysis of Independence—Liner Type (Whole Site)	C-2-1
	Appendix D: Additional Analyses—Two-Factor Landfill Site Characteristics Census	D-1

Acknowledgments

The information in this report was provided by GeoSyntec Consultants, Inc. (contractor) of Walnut Creek, California with support by GeoSyntec's Huntington Beach, California and Boxborough, Massachusetts, offices.

Executive Summary

This report presents the results of work completed by GeoSyntec Consultants, Inc. (GeoSyntec) and its subcontractors under Task 3 of the Landfill Facility Compliance Study for the California Integrated Waste Management Board (CIWMB). Phase I includes Tasks 1–3 (compiling a checklist of pertinent environmental regulatory requirements, developing a cross-media database inventory of 224 California municipal solid waste (MSW) landfills, and assessing MSW landfill environmental performance for the time period from January 1998 through December 2001). The Phase 1 Report presents the results of the Task 3 screening analyses performed on the Task 2 cross-media database inventory.

The 224 California MSW landfills included as part of Task 2 of this project were those that accepted waste since October 9, 1993. Initial data for each site was collected at various regulatory offices throughout the state and then finalized during two separate comment periods. The first comment period was open for landfill owner and operator review and comments. The second comment period was open for review and comments by landfill owners, operators, and regulators.

Each landfill was categorized by various site characteristics, including physical and social setting features, operational features, and design features. This report presents a distribution for each site characteristic, showing the number of landfills in each category, which provides the reader a snapshot of the state of landfill design and operation for the time of the study.

This report also presents the results of statistical analyses conducted to evaluate the relationships between various site characteristics and the environmental performance of the site. For these analyses, the actions taken by the various regulators were used as indicators of environmental performance. Because the study was designed as a cross-media study of landfill performance, the following five indicators were established to represent environmental performance as it relates to the site's groundwater, surface water, and air quality: "In Corrective Action," "Has Gas Inspection Report," "Has Gas Enforcement Action," "Has Surface Water Action," and "Air Quality Violation." The analyses were conducted to explore whether the available data indicate any statistically significant relationships between site characteristics and the environmental performance indicators.

The results of the statistical analyses demonstrate that sites most likely to be in corrective action or to have water-related cleanup and abatement orders are larger, located in urban areas, at least partially unlined, and located in areas of higher-than-average precipitation. In contrast, small, rural, unlined sites in dry climates tend to have a lower occurrence of corrective action or water-related cleanup and abatement orders. The results of the statistical analyses further demonstrate that landfills in drier climates tend to have fewer surface water compliance issues, including leachate seeps and excessive erosion. Additionally, sites that have undergone closure have a significantly lower occurrence of surface water actions.

The results also show the typical MSW landfill in California is publicly owned, active, located inland, fully unlined or partially unlined in the case of active sites, fully uncovered, and has no gas collection system. The typical site is underlain by sand and/or gravel, has a minimum depth to underlying groundwater of 34.5 feet, and receives an average annual precipitation of 16 inches.

This report also contains a list of 40 MSW landfills selected from the original 224 MSW landfills that will be the subject of the Phase II portion of the Landfill Facility Compliance Study, assessment of regulatory effectiveness. These 40 sites will be joined with 13 sites that closed prior to 1993, to provide a longer closure period for the regulatory assessment.

1 Introduction

This report presents the results of work completed by GeoSyntec Consultants, Inc. (GeoSyntec) and its subcontractors under Task 3 of the Landfill Facility Compliance Study for the California Integrated Waste Management Board (CIWMB). Phase I includes Tasks 1–3 (compiling a checklist of pertinent environmental regulatory requirements, developing a cross-media database inventory of 224 California municipal solid waste (MSW) landfills, and assessing MSW landfill environmental performance for the time period from January 1998 through December 2001). Phase II consists of Tasks 4–8 (these tasks include assessing the effectiveness of current regulatory requirements in controlling environmental impacts over time).^{*} The following items are actions taken to satisfy requirements in the Task 3 scope of work:

- Categorize California’s MSW landfills with respect to various quantifiable site characteristics, including liner type, site status, physical setting, and average annual precipitation.
- Develop screening criteria for evaluating the environmental performance of MSW landfills.
- Perform analyses of the site characteristic categories, summarizing by category (not specific landfills), the environmental performance (i.e., regulatory compliance) of the landfills. Analyses would include evaluating any commonality of factors pertaining to the environmental performance of the landfills.
- Recommend 40 MSW landfills for inclusion in the Phase II assessment.
- Provide a brief overview of solid waste landfills in California that do not receive MSW.

The emphasis of this report is to perform statistical analyses that help one understand the relationship between various factors that are assumed to be “independent” (for example, owner type or social setting) and conditions that reflect environmental performance of the sites (“dependent” factors). For this study, it has been assumed that environmental performance of the site can be represented by the number of regulatory actions imposed on the site, such as in regard to monitoring status of the site. Detailed statistical analyses are performed to evaluate the relationship between various dependent and independent factors and to test the assumptions made in the analyses.

1.1 Background Data Collection

The analyses presented in this report were conducted using the information collected for and contained in the relational database completed as part of Task 2 of this project. In accordance with the Task 2 scope of work, GeoSyntec compiled a database inventory of 224 California MSW landfills for the CIWMB. The 224 California MSW landfills included as part of Task 2 were those that accepted waste since October 9, 1993. This date was chosen as the cutoff date, since it was the effective date for Part 258 of Title 40 of the Code of Federal Regulations (40 CFR 258), also known as Subtitle D, which was the first comprehensive federal standard for MSW landfills.

The information on the 224 MSW landfills in the database includes general site characteristics (for example, owner type, age, size, social setting, and liner type) and environmental performance information collected during the period from January 1, 1998, to December 31, 2001. (The timeframe was initially shorter, but was extended to incorporate comments received from owners and operators

^{*} A description of the Landfill Facility Compliance Study and progress updates may be found on the CIWMB’s Web site at www.ciwmb.ca.gov/Landfills/.

during the first comment period, described in section 1.1.1.) Any changes that occurred after December 31, 2001, are not reflected in this report.

The database included information gathered by GeoSyntec during file reviews at each regional water quality control board (RWQCB), enforcement agency (EA), and air quality management/air pollution control district (AQMD/APCD) office from September 2000 through May 2001. Sources for the collected data were referenced throughout the database. In accordance with the approved scope of work and budget, the time allotted to collect all information was limited and had to be divided between the RWQCB office, the EA office, and the AQMD/APCD office. GeoSyntec submitted the first draft database to the CIWMB in September 2001.

Recognizing the limitations of the relatively brief file review period, the CIWMB forwarded the database information first to the respective landfill owners and operators and later to regulators, requesting verification, comments, and corrections regarding each site, as appropriate.

To finalize the database, there were two separate comment periods. The first comment period was open for owner and operator comments (Section 1.1.1). The second comment period was open for owner, operator, and regulator comments (Section 1.1.2).

1.1.1 Review and Comment Period One

During the first comment period, the owners and operators were requested to submit their comments and corrections to the CIWMB by November 26, 2001. A total of 111 sets of comments was received by the CIWMB during this first period. These comments were then forwarded to GeoSyntec via e-mail. Owner/operator comments continued to be received for four months following the November 26, 2001 deadline. GeoSyntec reviewed the owner/operator comments forwarded by the CIWMB through March 25, 2002 and incorporated them, as appropriate, in the database.

GeoSyntec recognized that even with the addition of owner and operator comments, gaps in the data existed. In late 2001, GeoSyntec asked each RWQCB to confirm the monitoring status for the sites within its jurisdiction. By the end of January 2002, each RWQCB had provided the monitoring status for each of its sites on the database. In some cases, the monitoring status provided by the RWQCB conflicted with the information provided by the owners and operators. The CIWMB then contacted the affected owners to provide them with another opportunity to comment.

After resolution of owner/operator comments on the monitoring status, GeoSyntec submitted a second draft of the database to CIWMB on May 14, 2002.

1.1.2 Review and Comment Period Two

As the initial Task 3 analyses of the database were conducted, it was found that even with the addition of owner and operator comments, there were still some gaps in the data. As a result, CIWMB staff reviewed its in-house library of landfill documents and worked with the State Water Resources Control Board (SWRCB) to fill these gaps. This review included the use of the CIWMB's Solid Waste Information System (SWIS) database to obtain EA inspection findings and enforcement actions.

Once these items were included, the CIWMB forwarded the draft database to each owner, operator, RWQCB, EA, and AQMD/APCD for comment. Each party was requested to submit its comments and corrections to the CIWMB by November 12, 2002. A total of 126 sets of comments was received by the CIWMB during this second comment period. These comments were then forwarded to GeoSyntec via mail or e-mail. Owner, operator, and regulator comments continued to be received for two months following the November 12, 2002, deadline. GeoSyntec reviewed the owner, operator, and regulator comments forwarded by the CIWMB through January 23, 2003, and incorporated them, as appropriate, in the final database.

1.1.3 Final Database

The final database was submitted to the CIWMB on February 4, 2003. On April 7, 2003, the CIWMB posted the final data inventory on its Web site at www.ciwmb.ca.gov/Landfills/ComplyStudy/db/.

While substantial efforts have been made to ensure the correctness and completeness of the data within the database, there are still undoubtedly errors in the dataset. As with any undertaking of this magnitude, some errors in measurement, interpretation, and data entry are inevitable. However, as the findings of the screening analyses presented in this report do not depend upon any single record but represent statistical analyses of a larger body of data, these findings are considered reliable with a relatively high level of confidence.

1.2 Report Organization

Section 2 of this report presents a brief overview of each of the landfill site characteristics used in the environmental performance analyses of the 224 MSW landfills contained in this study, including the liner type, site status, physical setting, and average annual precipitation. At the same time, this information provides the reader a snapshot of the state of landfill design and operation for the time of the study, January 1998 through December 2001.

Section 3 presents the screening methodology used to evaluate the relationships between each landfill site characteristic and environmental performance for the data contained in the database. It describes the selection and classification of the data and the statistical methods used to evaluate possible relationships.

Section 4 summarizes the results of the environmental performance screening analyses by each landfill site characteristic.

Section 5 summarizes the results of multiple variable analyses of landfill site characteristics, including:

- A profile of a “typical” landfill.
- A brief overview of the design and operational characteristics of urban, suburban, and rural landfills.
- A review of the environmental performance for urban, suburban, and rural landfills by multiple landfill site characteristics.
- A review of the environmental performance for active, inactive, closed, and combination landfills by multiple site characteristics.

Conclusions from the screening analyses are presented in Section 6.

The 40 MSW landfills selected for the Phase II portion of the study are presented in Section 7.

In addition to analyses of the 224 MSW landfills, a brief overview is provided in Appendix A on eight solid waste landfills that do not receive MSW. The purpose of this overview is to advise the reader of another set of solid waste landfills that are not addressed by the contracted study.

The results of the screening analyses of the 224 MSW landfills, including summary tables and charts, are included in Appendices B-2 through D.

2 MSW Landfill Site Characteristics Used in Analyses

2.1 *Introduction*

This section presents a brief overview of each of the landfill site characteristics used in the environmental performance analyses of the 224 MSW landfills contained in this study. At the same time, this information provides the reader a snapshot of the state of landfill design and operation for the time of the study, January 1998 through December 2001. The following landfill site characteristics were selected to provide a cross-environmental media view for the analysis of environmental performance:

1. Owner type.
2. Landfill age.
3. Landfill size.
4. Social setting.
5. Physical setting.
6. Underlying geologic material.
7. Minimum depth to underlying groundwater.
8. Average annual precipitation.
9. Liner type.
10. Final cover type.
11. Landfill gas collection system.
12. Site status.
13. Fill method.

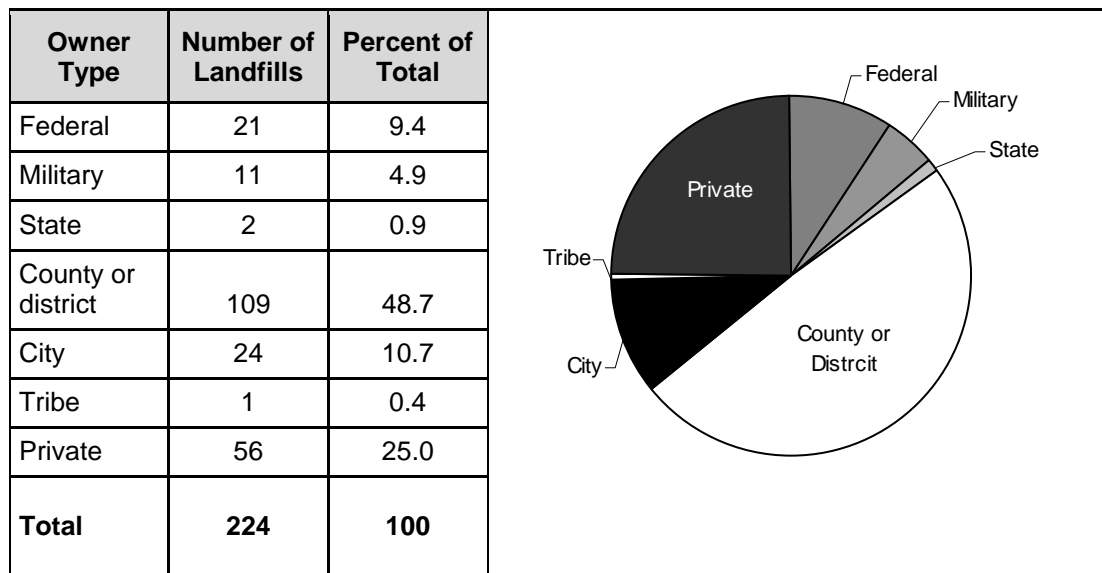
Each site characteristic is described and broken down into appropriate sub-components (that is, categories). For the 224 landfills contained in the study, a distribution is provided for each site characteristic showing the number of landfills in each category. The distribution shows the percentage of the 224 landfills this represents. For example, the Social Setting site characteristic is divided into three categories (urban, suburban, and rural). The distribution shows that for the 224 landfills, 71 are urban (31.7 percent), 14 are suburban (6.3 percent), and 139 are rural (62.1 percent). The distribution data is derived from the information contained in the Task 2 database and covers January 1998 through December 2001.

2.2 *Landfill Site Characteristics*

2.2.1 **Owner Type**

During the data collection, seven different ownership categories were identified, including federal, military, State, county or district, city, tribe, and private. The county or district category has the largest number of sites with approximately 49 percent of the total. The distribution of owner type is shown in Figure 2.1.

Figure 2.1: Distribution of Owner Type

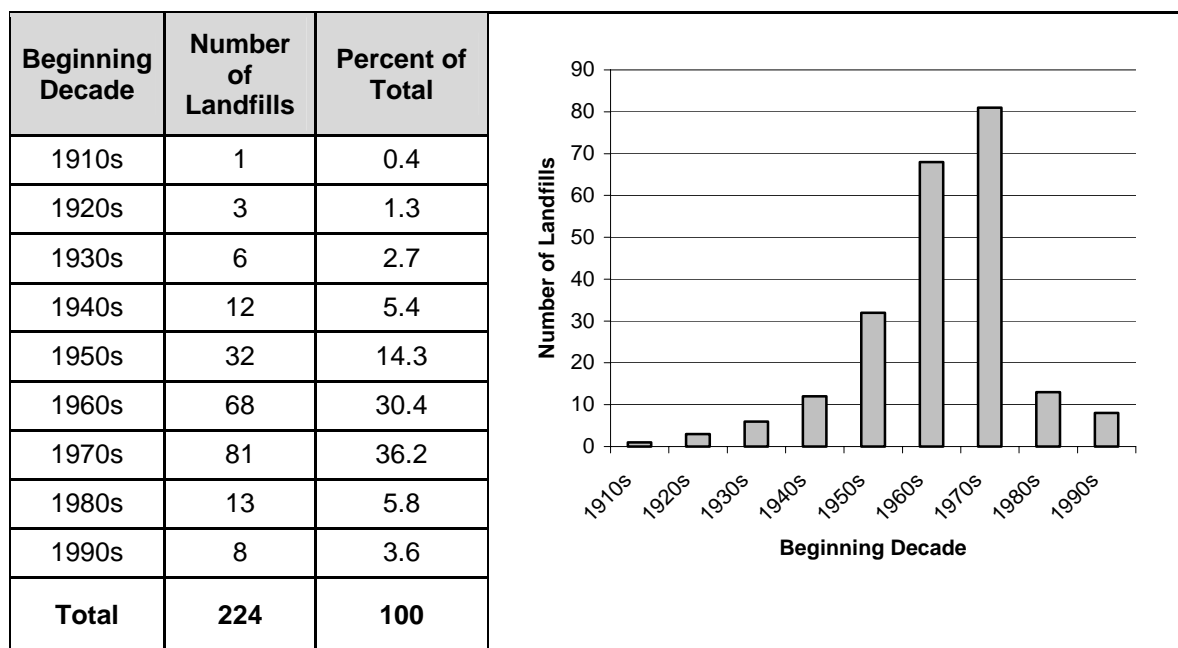


Grouping all public entities, 168 sites, or 75 percent, have public ownership and 56 sites, or 25 percent, have private ownership.

2.2.2 Landfill Age

The landfill age was estimated based on the reported date that the landfill first began receiving waste. The oldest landfill in the study began receiving waste in 1917; the youngest, in 1995. The mean year of first receipt of waste is 1965. By decade, the 1970s had the highest number of beginning landfill operations with 81, or 36 percent of the total. Figure 2.2 shows the distribution decade in which landfills began receiving waste.

Figure 2.2 Distribution of Landfill Age



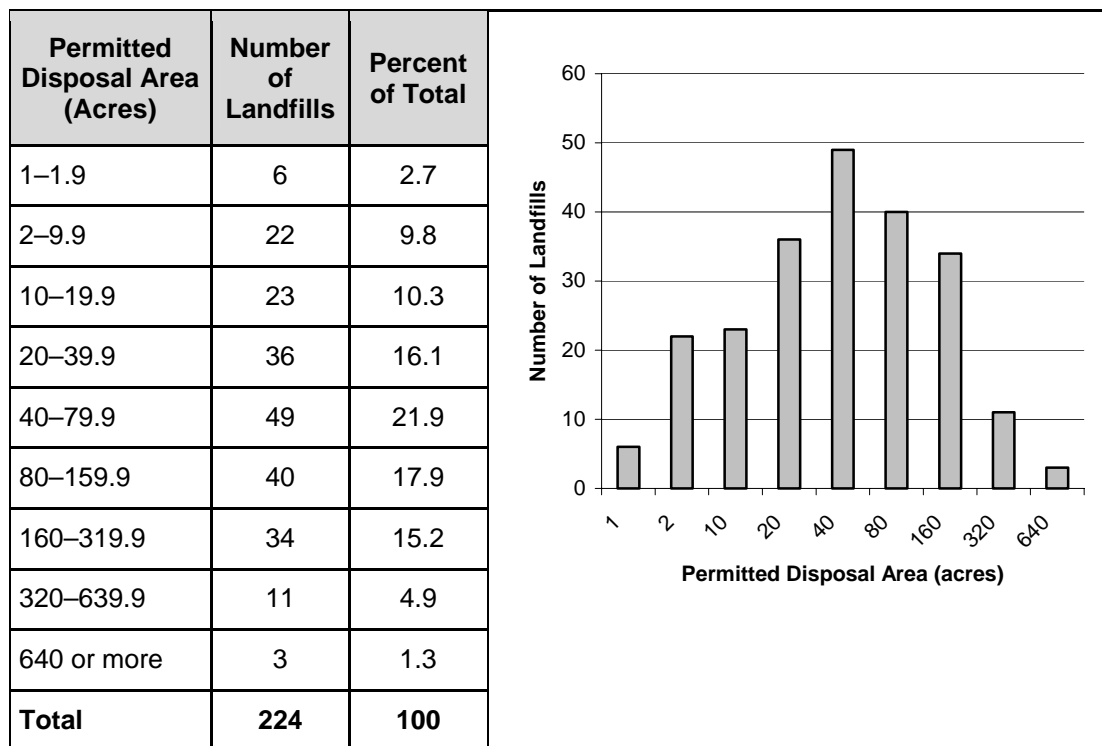
2.2.3 Landfill Size

The size of the landfills was categorized based on four different data sets, as follows:

1. Permitted disposal area in acres.
2. Permitted disposal volume in cubic yards.
3. Permitted maximum daily tonnage.
4. Estimated remaining capacity in cubic yards.

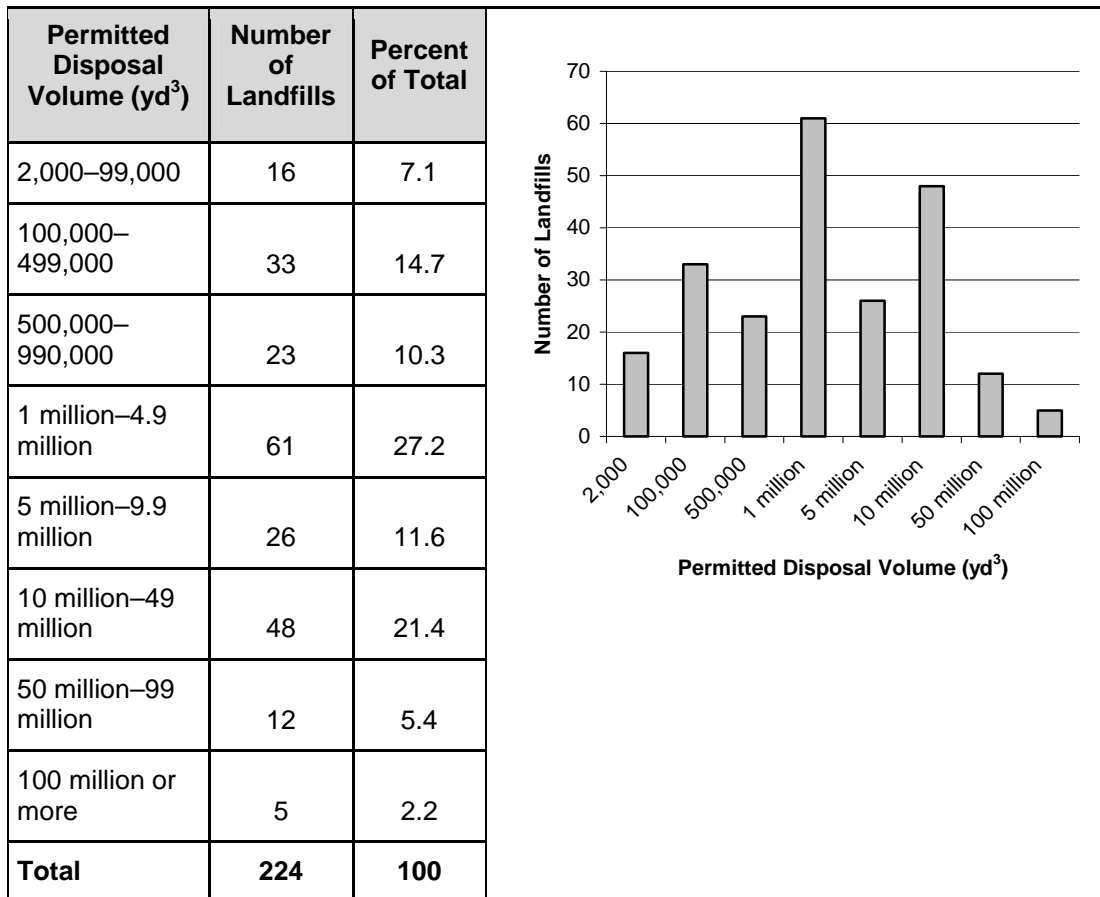
Permitted disposal area is the plan area of the landfill property that is permitted, generally by the solid waste facilities permit (SWFP) for the disposal of solid waste. This area is often referred to as the permitted waste footprint. The permitted disposal areas ranged from 1 acre to 800 acres. The average permitted area was 105 acres and the median was 55.5 acres. The distribution of permitted disposal area is shown in Figure 2.3.

Figure 2.3 Distribution of Permitted Disposal Area



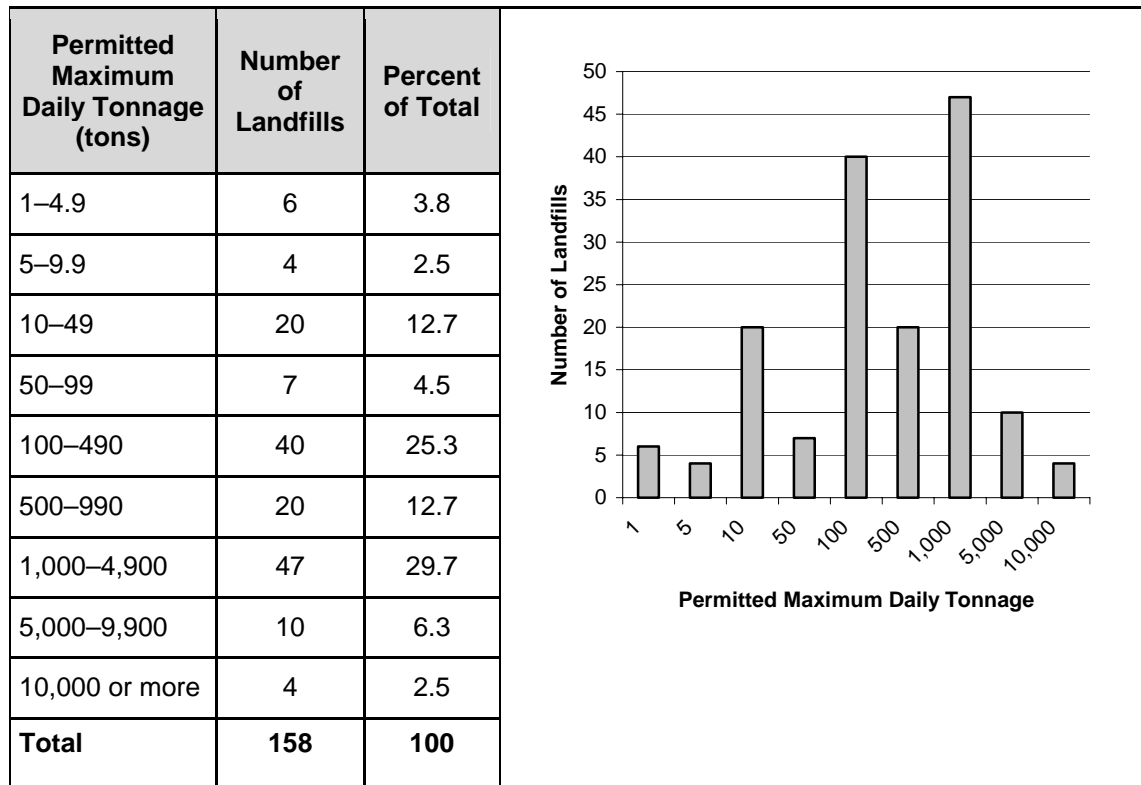
Permitted disposal volume is the total volume of the landfill space that is permitted (generally by the SWFP) for the disposal of solid waste. This volume is often referred to as the site capacity. The permitted disposal volume ranged from 2,100 cubic yards to approximately 185 million cubic yards. The median volume was 2.7 million cubic yards. The distribution of permitted disposal volume is shown in Figure 2.4.

Figure 2.4: Distribution of Permitted Disposal Volume



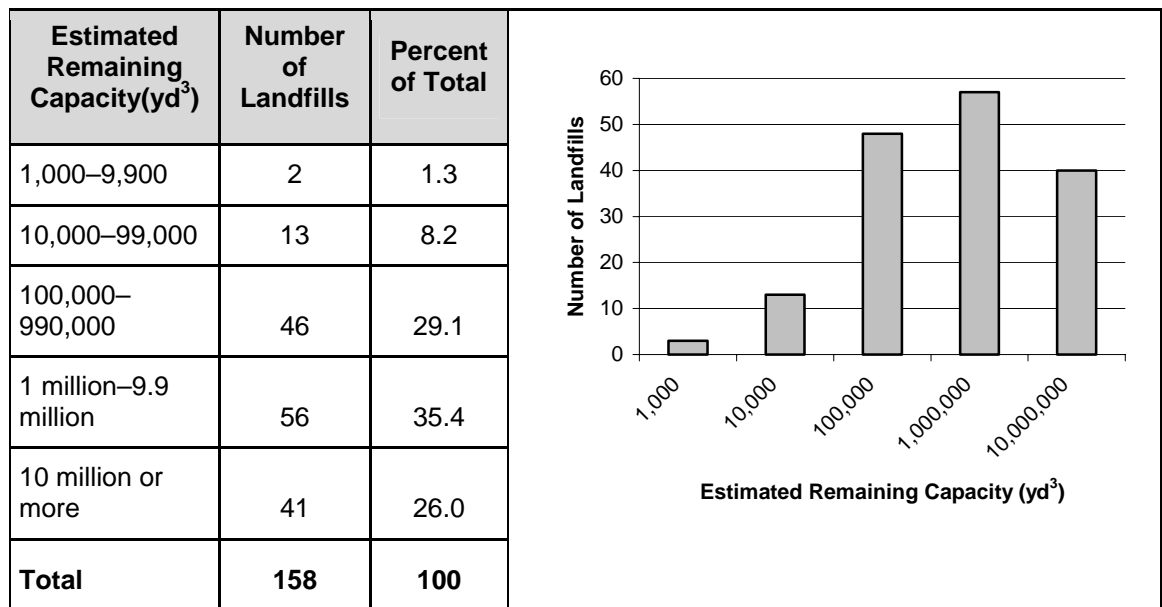
Permitted maximum daily tonnage is the tonnage of solid waste that is permitted (generally by the SWFP) to be disposed per day at the landfill. This standard can be waived by the CIWMB when a local emergency or state of emergency has been officially proclaimed. For this analysis, only the 158 active or partially active sites were included. For the closed and inactive sites, the daily tonnage is effectively zero. The permitted maximum daily tonnage for the time frame of the study ranged from 1 ton to 13,200 tons. The median tonnage was 385 tons. For the entire state, the permitted maximum daily tonnage was approximately 195,500 tons, which equates to approximately 11.5 pounds of MSW per person per day. The distribution of permitted disposal volume is shown in Figure 2.5.

Figure 2.5: Distribution of Permitted Maximum Daily Tonnage (Active Sites Only)



Estimated remaining capacity is the reported portion of the permitted disposal volume that has not yet been filled with solid waste. This data came from many sources, including financial assurance reporting, permits, closure plans, and periodic site reviews. For this analysis, only the 158 active or partially active sites were included. The remaining capacity is effectively zero for the closed and inactive sites. The remaining capacity for the landfills during the time frame of the study ranged from approximately 2,000 cubic yards to approximately 95 million cubic yards. The median remaining capacity was 2,153,800 cubic yards. For the entire state, the total remaining capacity was approximately 1.5 billion cubic yards, which equates to approximately 44 cubic yards per person. This is roughly equivalent to a cube that is 11 feet by 11 feet by 11 feet. The distribution of estimated remaining capacity is shown in Figure 2.6.

Figure 2.6: Distribution of Estimated Remaining Capacity (active sites only)



In general, California's remaining capacity for the time frame of the study was concentrated around the population centers (may include surrounding counties) of Los Angeles, San Francisco, Sacramento, and San Diego as shown in Figure 2.7. In this figure, the area of each dot is proportional to the county's remaining capacity.

Figure 2.7: Geographic Distribution of Estimated Remaining Capacity (active sites only)



Based on the Task 2 database information gathered for the period from January 1, 1998, to December 31, 2001, the following nine counties had no remaining MSW capacity: Alpine, Mendocino, Modoc, Nevada, San Francisco, Sutter, Tehama, and Trinity. Between 2001 and the date of this report, additional landfills have closed or become inactive. This created an additional three counties with zero remaining capacity, including Del Norte, Humboldt, and Tuolumne. Note that these estimates of remaining capacity do not include the capacity of proposed landfills that had not received waste as of December 3, 2001.

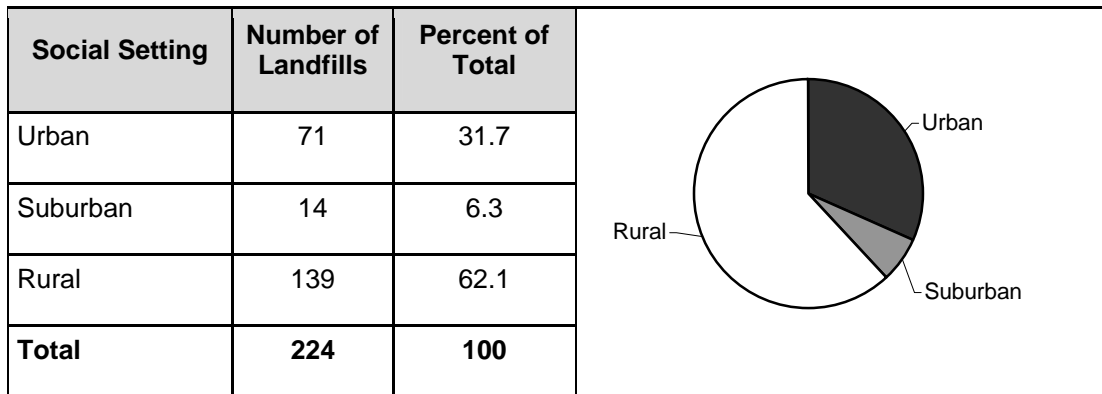
2.2.4 Social Setting

The categorization for social setting was based on the population density around the landfill. For this study, the following three categories were used based on U.S. Census Bureau's Census 2000 ZIP Code Tabulation Areas and census tract data files:

1. **Urban:** Includes areas with 50,000 or more people. The urban area data was obtained from www.census.gov/geo/www/cob/ua_metadata.html.
2. **Suburban:** Includes census tracts with 25,000 to 50,000 people. The 2000 census tract data was obtained from the Environmental Systems Research Institute.
3. **Rural:** Includes census tracts with fewer than 25,000 people.

The "Rural" category had the largest number of sites with approximately 62.1 percent of the total with 139 landfills. Figure 2.8 presents the distribution of social setting.

Figure 2.8: Distribution of Social Setting



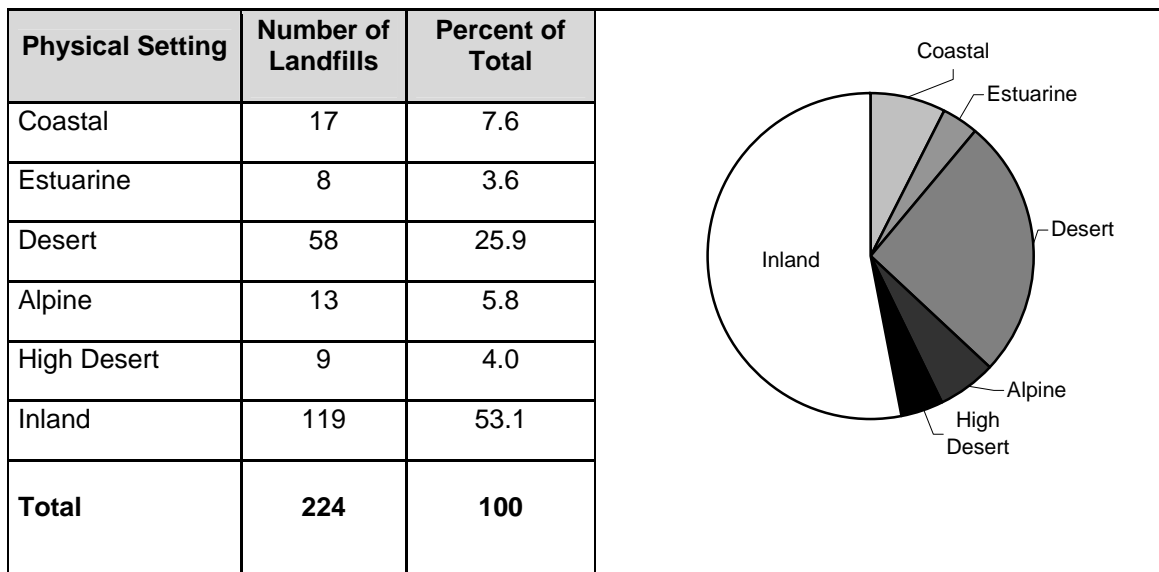
2.2.5 Physical Setting

The physical setting of the landfills was categorized based on certain topographic and climatologic characteristics. For this study, the following six categories were used:

1. **Coastal:** Between the ocean and first major ridge of mountains.
2. **Estuarine:** Along a bay/estuary.
3. **Desert:** Where less than 10 inches (25.4 millimeters) of precipitation per year are normally received as rain.
4. **Alpine:** Higher than 5,000 feet (1,524 meters) above mean sea level and/or where more than 50 percent of the annual precipitation is normally received as snow.
5. **High Desert:** Where both desert and alpine criteria are met.
6. **Inland:** All other locations that do not meet the above criteria.

The inland category had the largest number of sites with approximately 53 percent of the total with 119 landfills. Figure 2.9 presents the distribution of physical setting.

Figure 2.9: Distribution of Physical Setting

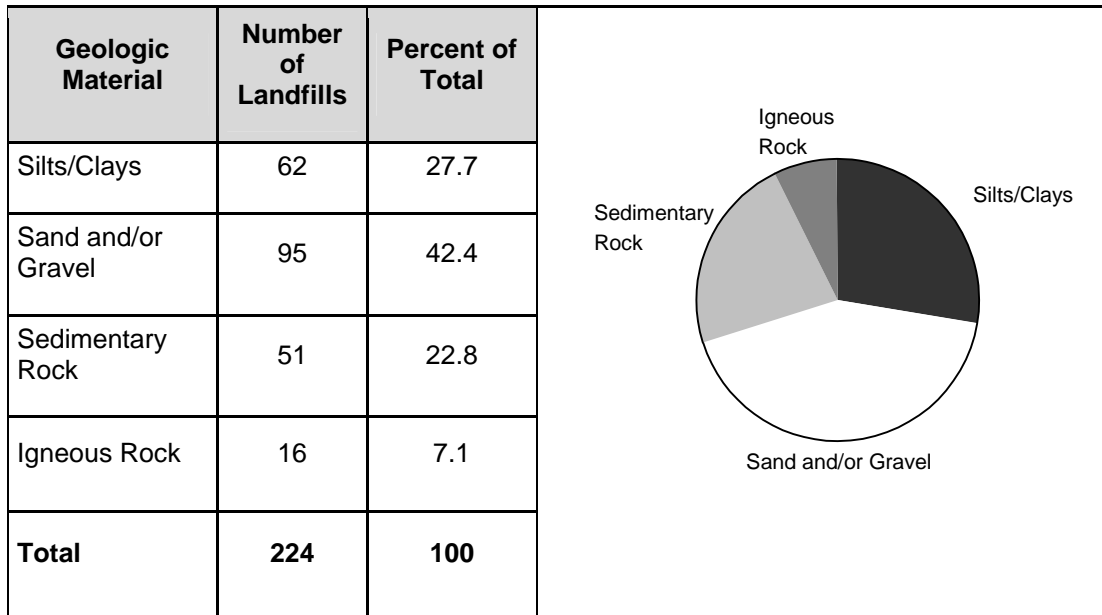


2.2.6 Underlying Geologic Material

The categorization for underlying geologic material was based on the type of native earthen material located beneath waste in landfills. For this study, the following four categories were used: silts/clays, sand and/or gravel, sedimentary rock, and igneous rock. When more than one type of geologic material was identified below a landfill, the predominant material was reported.

The “Sand and/or Gravel” category had the largest number of sites, 95 landfills (approximately 42.4 percent of the total). Figure 2.10 presents the distribution of underlying geologic material.

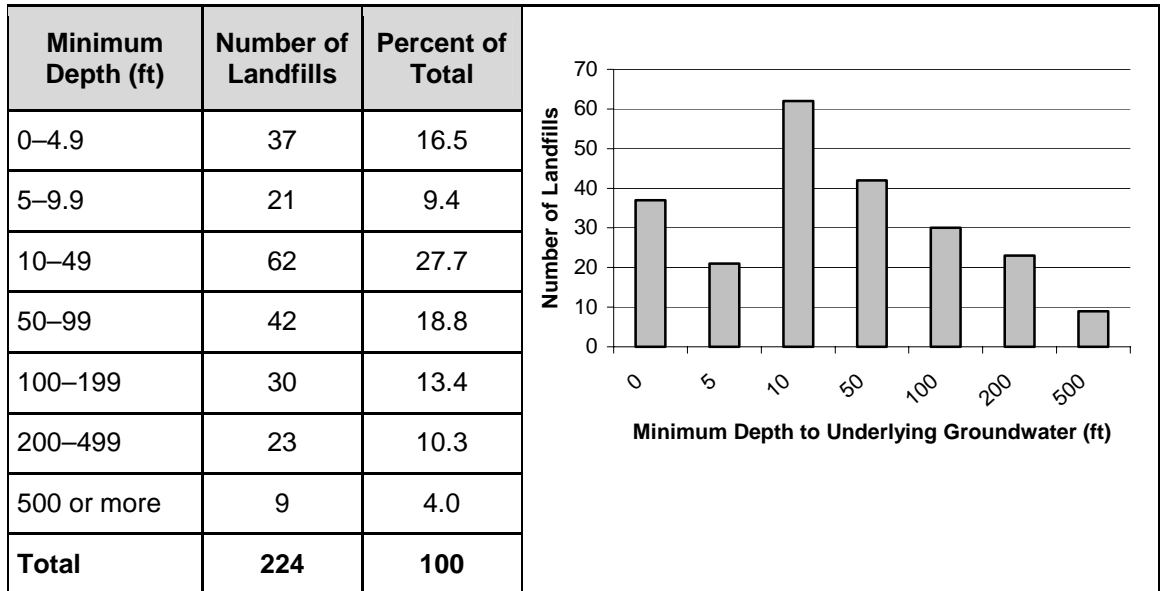
Figure 2.10: Distribution of Underlying Geologic Material



2.2.7 Minimum Depth to Underlying Groundwater

Title 27 of the California Code of Regulations (27 CCR) (Division 2, Subdivision 1, Chapter 2) defines underlying groundwater as "...water which rises above the zone of saturation due to capillary forces." The reported minimum distance between waste and underlying groundwater ranged from zero to more than 1,000 feet. The median depth to groundwater was 34.5 feet. The distribution of minimum depth to underlying groundwater is shown in Figure 2.11.

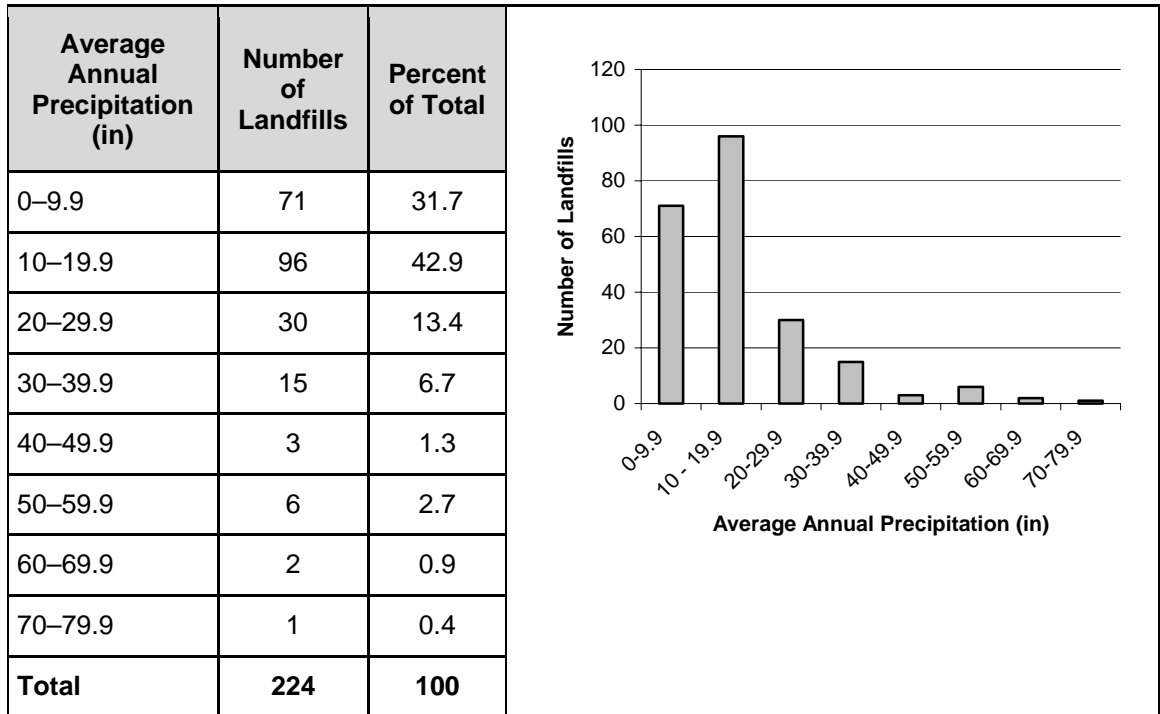
Figure 2.11: Distribution of Minimum Depth to Underlying Groundwater



2.2.8 Average Annual Precipitation

The reported average annual precipitation ranged from 2 inches to 74 inches. The mean annual precipitation was 16 inches. The distribution of average annual precipitation is shown in Figure 2.12.

Figure 2.12: Distribution of Average Annual Precipitation



2.2.9 Liner Type

Landfills can consist of one or more waste management units (WMU), where waste is disposed. The containment system for each WMU can be divided into four primary categories as follows:

1. **Fully Lined Subtitle D:** Includes landfills in which all of the WMUs at a landfill are entirely lined in accordance with the design requirements in the CFR (40 CFR 258) for a liner system. This category includes those sites with an approved engineered alternative to the Subtitle D prescriptive standard (such as a geosynthetic clay liner in lieu of a compacted clay liner.) Note that disposal areas that pre-date Subtitle D are not required to have Subtitle D liners.
2. **Fully Lined–Partially Non-Subtitle D:** Includes landfills in which all of the WMUs are entirely lined but with at least one portion of a WMU with a liner that does not meet the Subtitle D design standards.
3. **Partially Unlined:** includes those landfill with a minimum of one portion (or WMU) with a liner and one portion (or WMU) without one.
4. **Fully Unlined:** Includes landfills whose WMUs are without any liner.

The “Fully Unlined” category had the largest number of sites, with approximately 62 percent of the total (138 landfills). Figure 2.13 presents the distribution of liner types for all 224 landfills. Note that if closed and inactive sites are excluded from this tally, fully unlined sites are reduced to approximately 52 percent of the total. The distribution of liner type for the active landfills is included in Figure 2.14.

Figure 2.13: Distribution of Liner Types (All 224 Landfills)

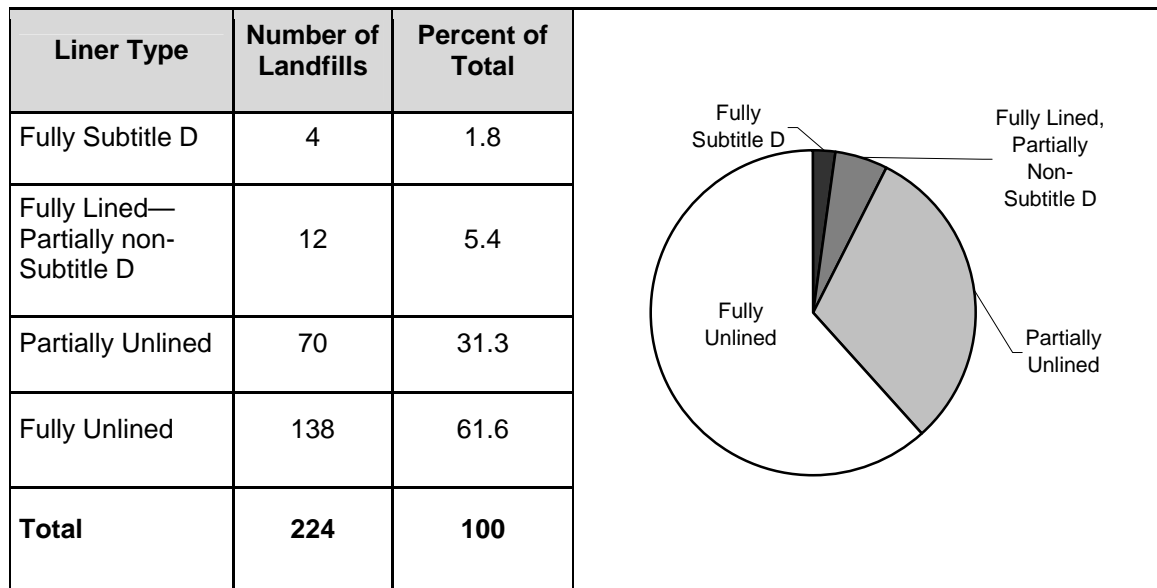
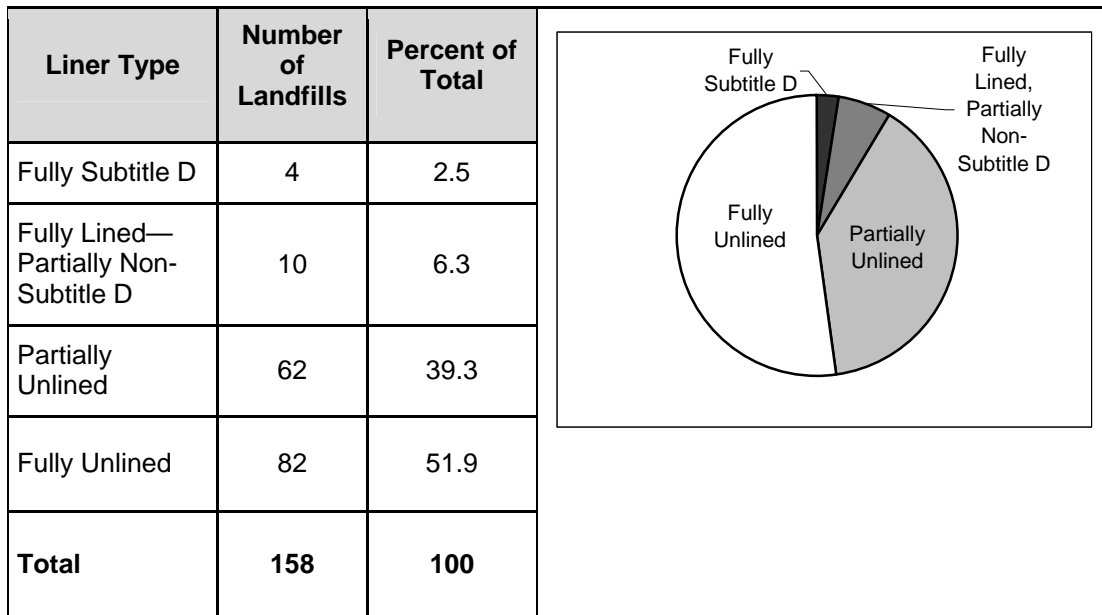


Figure 2.14: Distribution of Liner Types (Active Sites Only)



The four fully Subtitle D-lined landfills are:

1. Keller Canyon Landfill.
2. Norcal Waste Systems Ostrom Road Landfill, Inc.
3. Sunshine Canyon Sanitary Landfill County Extension.
4. CWMI Kettleman Hills Facility (however several non-Subtitle D impoundments exist on-site).

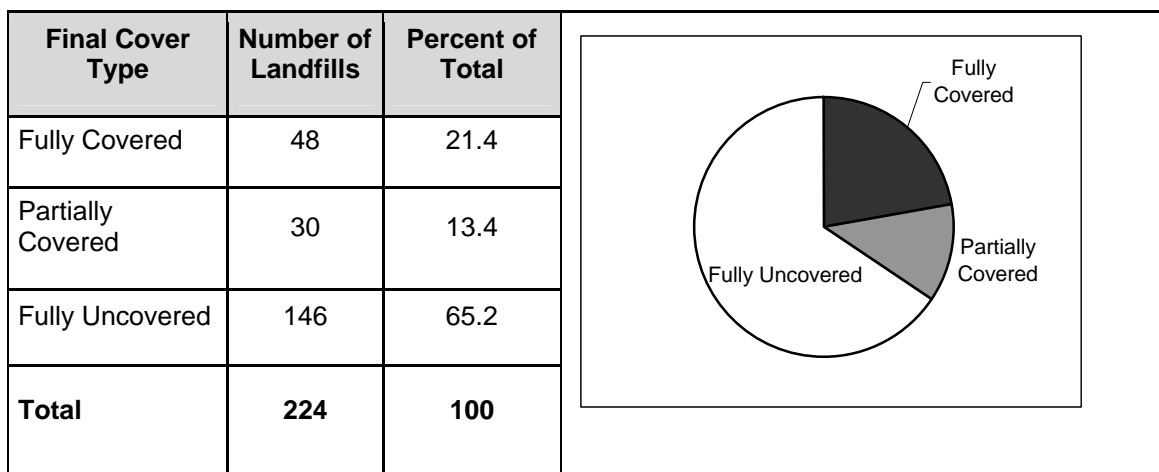
2.2.10 Final Cover Type

The status of final cover systems at each landfill was recorded. Future planned cover construction was not included and only existing final covers were reported. Since landfills can consist of one or more WMU, the final cover type for each WMU can be divided into the following three categories:

1. **Fully Covered:** Includes landfills in which all of the WMUs at a landfill are entirely covered with a final cover.
2. **Partially Covered:** Includes landfills where at least one WMU (or portion thereof) is covered with a final cover and another WMU (or portion thereof) is not covered with a final cover.
3. **Fully Uncovered:** Includes landfills whose WMUs are not covered with a final cover.

The fully uncovered category had the largest number of sites with approximately 65 percent of the 224 landfills (146 landfills). Note that the 146 landfills include many sites that are currently operating and are not required to construct a final cover until the time of closure. Figure 2.15 presents the distribution of final cover status for all 224 landfills. At the time of the study, 66 of the 224 landfills in this study were not accepting waste. Of these 66 landfills, 24 (36 percent) were also not fully covered. Generally, these sites were in the process of closure or awaiting regulatory approval for the construction of a cover.

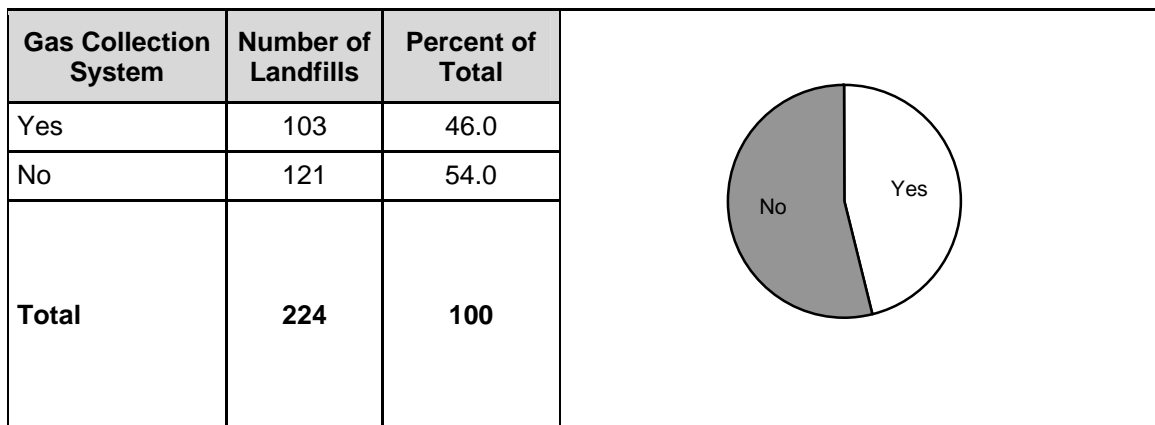
Figure 2.15: Distribution of Final Cover Types



2.2.11 Landfill Gas Collection System

Federal regulations (40 CFR Part 60, Subpart WWW: Standards of Performance for New Stationary Sources and 40 CFR Part 60, Subpart Cc: Emission Guidelines for Control of Existing Sources) require that when an operating landfill is larger than 2.5 million cubic meters or 2.5 million grams in capacity or when the landfill has non-methane organic compound emissions in excess of 50 million grams per year, the discharger must install a system to extract and control the gases generated at the landfill. In other cases, a landfill gas collection system may be required as part of a corrective action program, and/or EA enforcement action. Of the 224 sites in the study, 103, or 46 percent, have engineered systems in place to collect landfill gas and 121 sites, or 54 percent, do not. This distribution is shown in Figure 2.16.

Figure 2.16: Distribution of Gas Collection Systems



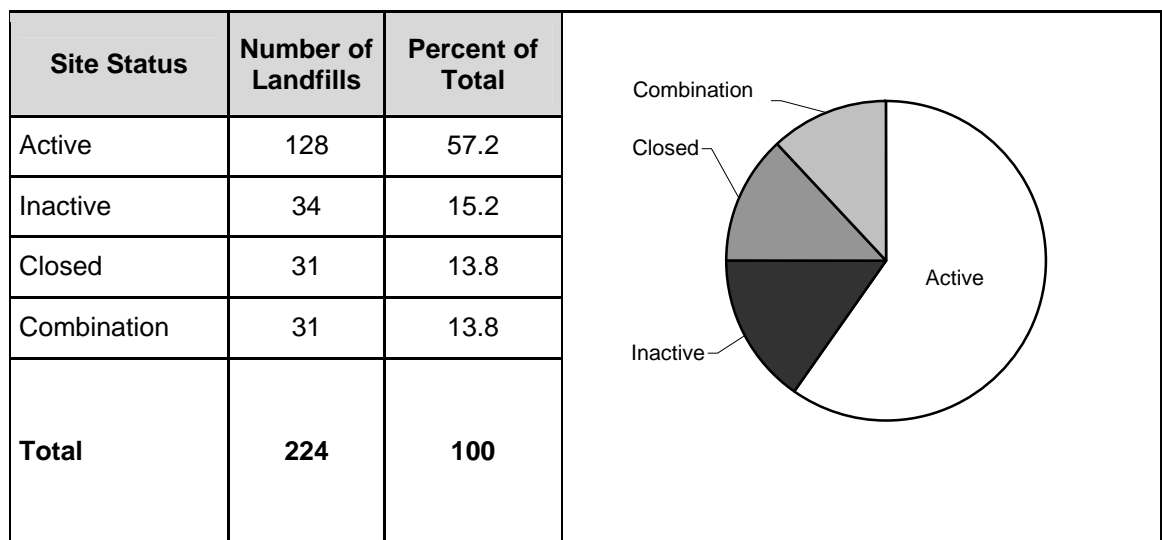
2.2.12 Site Status

The site status is the operational state of the MSW landfill during the time of the study—from January 1, 1998, to December 31, 2001. For this study, the following four categories were used:

1. **Active:** The landfill was accepting solid waste for disposal during the time of the study.
2. **Inactive:** The landfill was not accepting solid waste for disposal during the time of the study and had not completed closure in accordance with applicable statutes, regulations, and local ordinances in effect during the time of the study.
3. **Closed:** The landfill had ceased accepting solid waste for disposal and had documented that closure was conducted in accordance with applicable statutes, regulations, and local ordinances in effect at the time of the study.
4. **Combination:** The landfill consisted of more than one waste management unit in different operational states at the time of the study (for example, one closed unit and one active unit).

The active category had the largest number of sites, 128, with approximately 57.2 percent of the total. With the addition of the 30 that are partially active (a subset of the 31 in the “Combination” category), the total number of sites with at least one waste management unit active is 158, or 71 percent of the total sites evaluated. Figure 2.17 presents the distribution of site status.

Figure 2.17: Distribution of Site Status



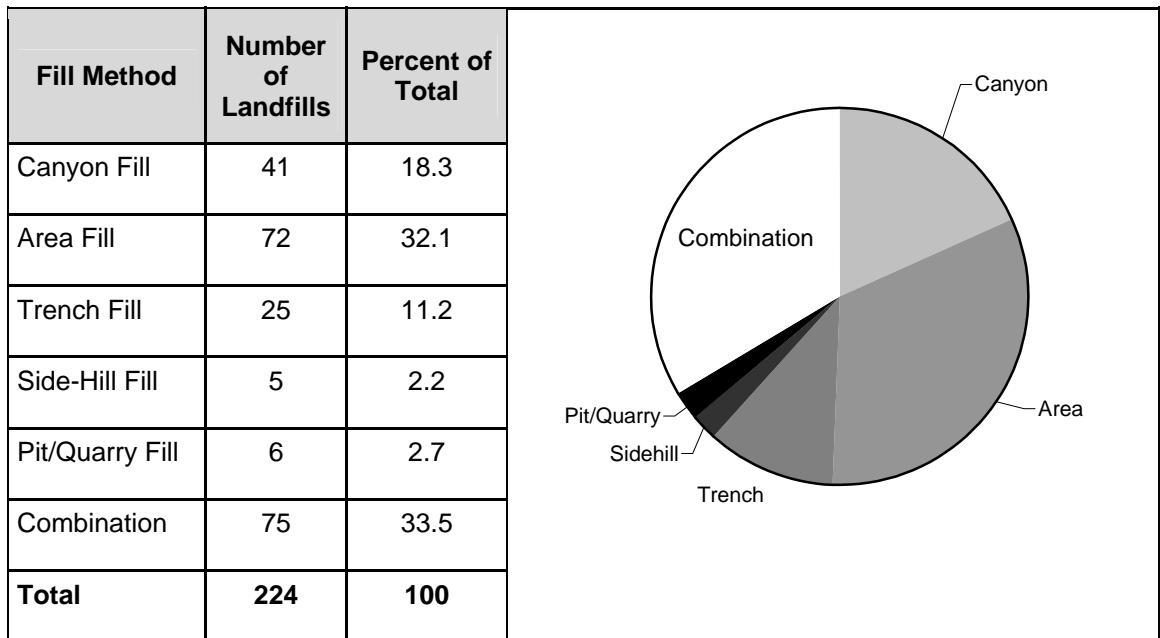
2.2.13 Fill Method

During placement of waste, different sites may use different filling methods. Additionally, any single site may have used more than one method throughout its history. Six fill methods were identified, and all landfills were classified into at least one of the methods. These fill methods and their descriptions are as follows:

1. **Canyon Fill:** Disposing of solid waste by filling in a canyon.
2. **Area Fill:** Disposing of solid waste by filling across a flat area.
3. **Trench Fill:** Disposing of solid waste by filling an excavated trench.
4. **Side-Hill Fill:** Disposing of solid waste by filling across a sloped area.
5. **Pit/Quarry Fill:** Disposing of solid waste by filling an existing pit or quarry that was excavated for a purpose other than waste disposal, such as a mining operation.
6. **Combination:** Disposing of solid waste by using more than one of the above methods.

Combination sites were the most common method, with 75 sites, or 33.5 percent of the total. Figure 2.18 shows the distribution fill method.

Figure 2.18 Distribution of Fill Methods



3 Methodology for Environmental Performance Screening Analyses

3.1 Introduction

Separate analyses were conducted to evaluate the relationships between landfill site characteristics and environmental performance for the data contained in the database. This section describes the selection and classification of the data and the statistical methods used to evaluate possible relationships.

3.2 Statistical Analysis Approach

For the purposes of the statistical analyses described in this section, the terms “independent” and “dependent” are used frequently to describe the assumed relationship between landfill site characteristics and environmental responses. In most analyses conducted in this study, the assumed independent variable represents a landfill site characteristic, such as owner type or average annual precipitation. The assumed dependent variable is a measure of environmental performance, such as “In Corrective Action,” typically described by a regulatory action. The terms “independent” and “dependent” refer to the relationship between the two variable types. It is assumed that the independent variable by itself results in certain dependent variable conditions, impacting the status or nature of these conditions. Therefore, the former variable is the “causative” one, and the latter is the “response” variable.

Analyses were conducted to explore whether the available data indicate any statistically significant relationships between independent site variables and the dependent environmental response variables. Logistic regression analyses were used for the categorical variables. For the continuous variables, non-parametric analysis of variance using the two-sample Kruskal-Wallis test (also known as the Mann-Whitney test) was used. A detailed description of the statistical methods is presented in Appendix B-1.

3.2.1 Assumed Independent Variables

For these analyses, the landfill site characteristics (such as owner type) contained in the Task 2 database were assumed to be the independent variables. Each independent variable either has at least two mutually exclusive values and/or a “continuous” value (steady stream of data). These landfill site characteristics that were evaluated and their possible values include:

1. *Owner Type* (public or private). Note that public landfills include all federal, State, county, district, tribe, and city landfills. Mutually exclusive variable.
2. *Landfill Age*. Analyses were performed using a continuous value (age 0–100 years) or mutually exclusive values (such as [1] construction during/before or after 1984 or [2] age in 20-year increments or ages outside the increments). Continuous or mutually exclusive variable.
3. *Landfill Size (Permitted Disposal Area)*. Continuous variable.
4. *Social Setting* (rural or non-rural). Note that non-rural settings include both urban and suburban landfills. Mutually exclusive variable.
5. *Physical Setting* (desert, coastal, alpine, high desert, estuarine, or inland). Mutually exclusive variable.
6. *Underlying Geologic Material* (sand and/or gravel, silts/clays, sedimentary rock, or igneous rock). Mutually exclusive variable.

7. *Minimum Depth to Underlying Groundwater*. Continuous variable.
8. *Average Annual Precipitation*. Continuous variable.
9. *Liner Type (Whole Site)* (fully Subtitle D or Subtitle D engineered alternative, fully lined and partially non-Subtitle D, partially unlined, or fully unlined). Mutually exclusive variable.
10. *Final Cover Type (Whole Site)* (fully covered, partially uncovered, or fully uncovered). Mutually exclusive variable.
11. *Landfill Gas Collection System* (Yes or No). Mutually exclusive variable.

3.2.2 Assumed Dependent (Environmental Response) Variables

The dependent variables are those that serve as indicators of environmental performance and can be dependent on the independent variables described above. As described in greater detail in Section 3.3 below, these are:

1. In Corrective Action.
2. Has Gas Inspection Report.
3. Has Gas Enforcement Action.
4. Has Surface Water Action.
5. Has Air Quality Violation.

3.3 Indicators of Environmental Performance

3.3.1 Approach and Assumptions

Typically, environmental performance for a landfill can be assessed based on the measured properties of the groundwater, leachate, air, soil, and surface water relative to some standard. The standard may be the background levels, historical values, or regulatory limits. Measurements for any given site, when observed over time, can be compared against a standard to evaluate the site's performance.

Because each site in this study has a unique physical and operating environment, examining the performance of all 224 sites with respect to each other represents an extremely complex analysis. Monitoring frequency, monitoring point location, background characteristics, historic measurements, constituents of concern, and reporting formats can vary greatly from site to site. Additionally, the amount of data required to make such an assessment is well beyond the scope of this work. Recognizing that quantifying environmental performance is a complex and difficult for any given site, much less 224 sites at once, an alternative measure of environmental performance was required.

For these analyses, the actions taken by the various regulators were used as an indicator of environmental performance. One duty that is entrusted to each regulator is to take action if certain environmental standards are not being met. Three principal assumptions must be made in order to use these types of regulatory actions as reliable indicators of environmental performance. The assumptions are as follows:

1. The monitoring systems at each site (such as groundwater wells and gas probes) are located, monitored, and reported in such a way that the site regulators have an adequate picture of the actual environmental performance.

2. The actions the regulators take are appropriate responses for actual environmental impacts. The assumption requires that when presented with the site-specific data, the regulator draws an appropriate conclusion and takes an appropriate action. For example, if there is strong groundwater monitoring evidence that a landfill is impacting the underlying groundwater, then it is assumed that the RWQCB would issue a cleanup and abatement order or would require a corrective action program.
3. The actions that regulators take are relatively uniform across the state. For example, if leachate seeps are observed by one EA in northern California and a leachate control violation is issued, then an EA in southern California observing identical seeps would also issue an identical leachate control violation.

For this screening-level analysis, these three assumptions are reasonable.

3.3.2 Sources for Indicators of Environmental Performance (Dependent Variables)

Because this study was designed as a cross-media study of landfill performance, the indicators of environmental performance were selected from the database with respect to the site's groundwater, surface water, and air. The selected variables are "In Corrective Action," "Has Gas Inspection Report," "Has Gas Enforcement Action," "Has Surface Water Action," and "Has Air Quality Violation." Table 3-A shows the regulatory agencies responsible for oversight of each of the environmental performance indicators.

Table 3-A: Regulatory Agencies That Oversee Environmental Performance Indicators

Regulatory Agency Overseeing Environmental Performance		Environmental Performance Indicator (Dependent Variable)
State Oversight	Local Oversight	
State Water Resources Control Board	Regional Water Quality Control Board	In Corrective Action
California Integrated Waste Management Board	Enforcement Agency	Has Gas Inspection Report
		Has Gas Enforcement Action
		Has Surface Water Action
California Air Resources Board	Air Districts	Air Quality Violation

RWQCB Information (Water-Related Environmental Performance)

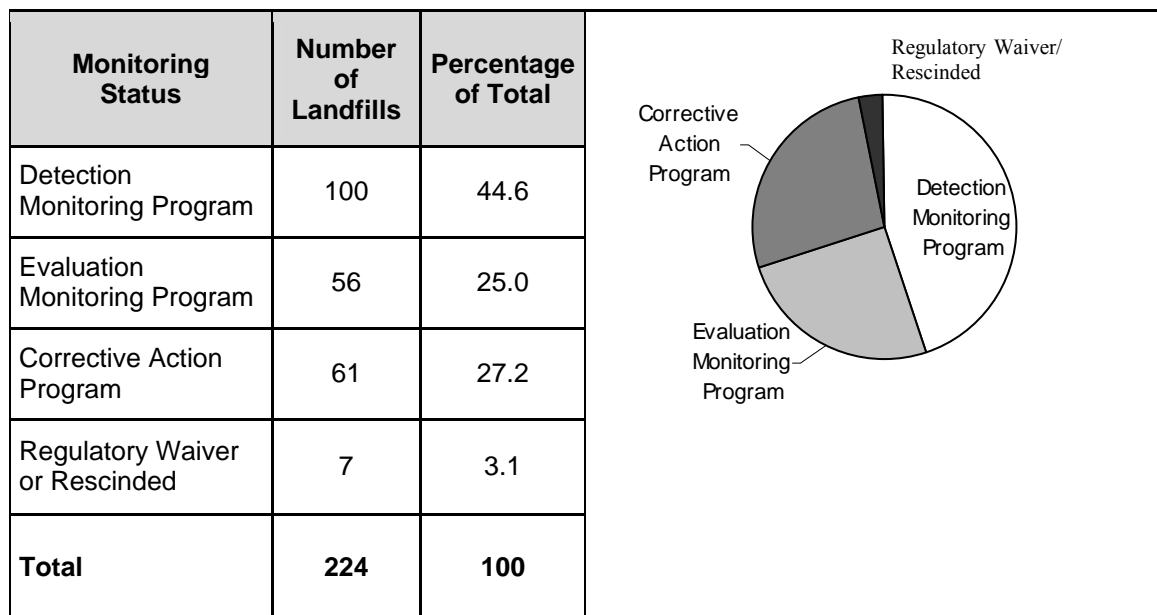
Monitoring status categories used by RWQCBs were chosen as the principal indicators for water-related environmental performance. This variable characterizes the state of groundwater, surface water, and unsaturated zone monitoring at an MSW landfill during the time of the study. Landfills are required to establish a monitoring program to detect at the earliest possible time a release from the landfill that could threaten water quality and to report this information to the RWQCB. The following four monitoring programs are required by State regulations:

1. **Detection Monitoring:** This is the general default monitoring program. The program initiated at the landfill must at a minimum comply with section 20420 of Title 27 of the CCR. Generally, at this level of monitoring, samples are collected to detect possible releases.

2. **Evaluation Monitoring:** This type of program is required to be instituted whenever there is “measurably significant” evidence of a release from the landfill during a detection monitoring program. An evaluation monitoring program initiated at a landfill must at a minimum comply with section 20425 of Title 27 of the CCR. At this level of monitoring, the nature and extent of the release from the landfill is assessed and a corrective action program is designed, if appropriate.
3. **Corrective Action:** This type of monitoring program is required to be instituted whenever the RWQCB determines that the nature and extent of a release (as determined from evaluation monitoring), and warrants corrective action. The corrective action program initiated at the landfill must at a minimum comply with section 20430 of Title 27 of the CCR. At this level, action is taken to remediate releases from the landfill to achieved compliance with the appropriate water quality standard.
4. **Regulatory Waiver or Rescinded:** This status indicates the landfill has a waiver from the monitoring requirements by the RWQCB, typically because the monitoring would be impractical or groundwater is at great depths beneath the landfill. Landfill monitoring requirements can be rescinded by the RWQCB when, in its judgment, the landfill no longer poses a potential threat to the waters of the state.

Looking at the distribution of this variable across the population of 224 landfills, Detection Monitoring had the largest number of sites, with approximately 45 percent (100 landfills) of the total. Figure 3.1 presents the distribution of RWQCB monitoring status for all 224 landfills.

Figure 3.1: Distribution of RWQCB Monitoring Status



Of the four, the corrective action program status is the most indicative of a known environmental impact. In addition to requiring a corrective action, an RWQCB may issue a cleanup and abatement order that requires action on the part of the landfill owner/operator to mitigate a problem. Because some RWQCBs are more likely to issue cleanup and abatement orders than to require corrective action programs, water-related cleanup and abatement orders were also used as an indicator of a site’s environmental performance.

Combining these two regulatory actions, the Boolean variable “In Corrective Action” was established. The two possible values of this variable are shown in Table 3-B.

Table 3-B: Possible Values of the “In Corrective Action” Variable

Value	Meaning
Yes	Landfill is either required to conduct a corrective action program <u>or</u> is under a water-related cleanup and abatement order.
No	Landfill is not required to conduct a corrective action program <u>and</u> is not under a water-related cleanup and abatement order.

EA Information (Gas-Related and Surface Water Environmental Performance)

For most landfills in this study, the EA inspects the site on a monthly basis to observe the site conditions for performance of the regulatory minimum standards. Based on the observations, the EA determines whether the landfill is in compliance with or in violation of each standard. Additionally, the EA may find that something is an “area of concern” (AOC), meaning the conditions may not be fully in compliance but not severe enough to report as a violation. An AOC is not a violation, but indicates a problem that could rise to the level of a violation if not corrected.

For this assessment, standards from the following gas-related sections in 27 CCR were used:

- 20919 **Gas Control:** Requires the owner of a landfill to implement a monitoring program if the EA, local fire control authority, or CIWMB believes a hazard or nuisance may be created by landfill decomposition gases. The program shall not be discontinued until authorized by the requiring agency.
- 20919.5 **Explosive Gasses Control:** Specifies concentration limits for methane gas in on-site structures and at the property boundary, and requires an owner or operator of a landfill to implement a routine methane monitoring program. Specifies the type and frequency of the monitoring. The EA with the concurrence from the CIWMB may establish alternative frequencies for MSW landfills that accept 20 tons or less per day.
- 20921 **Gas Monitoring and Control During Closure and Postclosure:** During the time of closure and postclosure, specifies concentration limits for methane gas and requires an owner or operator of a landfill to implement a routine methane gas monitoring program.
- 21160 **Gas Control/Leachate Contact:** Requires the operator of a landfill to implement and maintain landfill gas control and prevent leachate contact with the public or animals. The owner or operator shall also assure that the leachate collection and removal system designed for the landfill does not interfere with landfill gas control nor promote landfill gas migration.

Combining gas-related inspection results for each standard above, the Boolean variable “Has Gas Inspection Report” was established. The two possible values of this variable are shown in Table 3-C.

Table 3-C: Possible Values of the “Has Gas Inspection Report” Variable

Value	Meaning
Yes	EA reported for the landfill at least one gas-related AOC or violation during the study period of January 1, 1998 through December 31, 2001.
No	EA did not report for the landfill any gas-related AOCs or violations during the study period of January 1, 1998 through December 31, 2001.

With repeated violations of the standards, the EA may issue an enforcement action. A variable was established based on the EA gas-related enforcement actions. For this study, the following types of enforcement actions were used:

- Notices and Orders: There are three types of orders, listed below.
 - (1) Corrective Action Order: An order requiring the owner or operator of a facility, disposal site, or operation to take specified action by a specified date to abate a nuisance, or to protect public health and safety or the environment. Typical circumstances under which this order may be issued: Conditions at the facility, disposal site, or operation are creating a nuisance or posing a threat to human health and safety or the environment.
 - (2) Cease and Desist Order: An order requiring the owner or operator of a facility, disposal site, or operation to cease and desist any improper action, as specified in PRC section 45005, by a specified date. Typical circumstances under which this order may be issued: Facility, disposal site or operation is in violation of Division 30 of the Public Resources Code, any regulations adopted pursuant to Division 30, or causes or threatens to cause a condition of hazard, pollution, or nuisance.
 - (3) Compliance Order: Upon any of the grounds specified in PRC section 45011(a)(1), an order establishing a time schedule according to which the owner or operator of the facility, disposal site, or operation shall correct any violations and/or abate a potential or actual threat to public health and safety or the environment. Typical circumstances under which this order may be issued: Facility, disposal site, or operation is in violation of Division 30 of the Public Resources Code, any regulations adopted pursuant to Division 30, any corrective action or cease or desist order, or poses a potential threat to public health and safety or the environment. A compliance order must be issued pursuant to PRC section 45011 as a prelude to the assessment of administrative civil penalties.
- Stipulated Notice and Order: A notice and order to which the EA and owner or operator of the facility, disposal site, or operation have agreed to the terms and conditions of the notice and order.
- Listed on CIWMB’s “Inventory of Solid Waste Facilities Violating State Minimum Standards.” (www.ciwmb.ca.gov/LEACentral/Inventory/). The inventory is a list of solid waste facilities in California that are violating the State Minimum Standards for solid waste handling and disposal. Three steps must be taken as part of due process in placing a facility on the inventory:

Step One: An EA documents, in two consecutive monthly inspection reports, violations of one or more standards identified as "state minimum standards" for solid waste handling and disposal in Title 14 or Title 27, California Code of Regulations (14 CCR or 27 CCR).

Step Two: When CIWMB staff note at least one violation for two consecutive months, a letter is sent to the operator of the facility notifying the operator of the CIWMB's intent to place the facility in the inventory if the violations are not corrected within 90 days of receipt of the notice. Such a letter is referred to as a "notice of intent" or NOI.

Step Three: On or after the 90th day subsequent to the operator's receipt of the NOI, if one or more of the violations noticed have not been corrected as documented in an inspection report submitted by the EA, CIWMB staff will send another letter to the operator, telling the operator that the facility has been placed on the inventory. A letter telling an operator that a facility is on the inventory is referred to as an "inclusion letter." Board staff may consult with the EA verbally before sending out either an NOI or an inclusion letter to confirm that each is based on accurate and up-to-date information.

Combining these gas-related enforcement actions, a Boolean variable, "Gas Enforcement Action," was established. The two possible values of this variable are shown in Table 3-D.

Table 3-D: Possible Values of the "Has Gas Enforcement Action" Variable

Value	Meaning
Yes	EA issued the landfill at least one gas-related enforcement action during the study period of January 1, 1998 through December 31, 2001.
No	EA did not issue the landfill any gas-related enforcement actions during the study period of January 1, 1998 through December 31, 2001.

In addition to the gas-related standards, a surface-water indicator was selected from the EA information. All EA-reported AOCs and violations for leachate control (27 CCR section §20790) were combined with all EA-reported AOCs and violations for drainage and erosion control (27 CCR section §20820) for the Boolean variable termed "Surface Water Action."

- 20790 Leachate Control: Operator shall ensure that leachate is controlled to prevent contact with the public.
- 20820 Drainage and Erosion Control: Drainage system shall be designed and maintained to ensure integrity of roads, structures, and gas monitoring and control systems; prevent safety hazards; and prevent exposure of waste.

The two possible values of this variable are shown in Table 3-E.

Table 3-E: Possible Values of the "Has Surface Water Action" Variable

Value	Meaning
Yes	EA reported for the landfill at least one leachate control AOC or violation or at least one drainage and erosion control enforcement action during the study period of January 1, 1998 through December 31, 2001.
No	EA did not report for the landfill any leachate control AOC or violations or drainage and erosion control enforcement action during the study period of January 1, 1998 through December 31, 2001.

AQMD/APCD Information (Air Quality Environmental Performance)

The final indicator of environmental performance was chosen from the information provided by AQMDs and APCDs. There are 35 air districts in California. Each district has established its own set of rules pertaining to landfills. These rules may vary slightly due to the areas they are in being classified as attainment or non-attainment zones for ozone. The majority of these rules were adopted to implement the federal requirements for “new” and “existing” larger MSW landfills. Some district landfill rules also apply to smaller landfills in an effort to obtain further VOC emission reductions.

The information on air quality environmental performance is from the following two AQMDs:

- South Coast Air Quality Management District (SCAQMD).
- Bay Area Air Quality Managements District (BAAQMD).

These two districts were chosen based on their large number of landfills and on the amount of information that was provided by each district for the Task 2 database.

Notices to comply and notices of violations issued by these two AQMDs were combined as an indicator of environmental performance and a Boolean variable was established termed “Air Quality Violation.” The two possible values of this variable are shown in Table 3-F.

Table 3-F: Possible Values of the “Has Air Quality Violation” Variable

Value	Meaning
Yes	The SCAQMD or the BAAQMD issued the landfill at least one notice to comply or notice of violation during the study period of January 1, 1998 through December 31, 2001.
No	Neither the SCAQMD nor the BAAQMD issued the landfill any notices to comply nor notices of violations during the study period of January 1, 1998 through December 31, 2001.

More detailed discussion of the relationships between the variables and analyses performed to evaluate those relationships is presented in Appendix B-1. The results of the statistical analyses are summarized in Section 4 and presented in detail in Appendices B-2 through D.

3.4 Relationship Between Assumed Independent Variables and Assumed Dependent Variables

In most analyses conducted in this study, the assumed independent variable represents a landfill site characteristic, such as *Annual Precipitation*. The assumed dependent variable is a measure of environmental performance, such as “In Corrective Action,” typically described by a regulatory action. It is assumed that the independent variable by itself results in certain dependent variable conditions. The terms “independent” and “dependent” refer to the relationship between the two variable types. The independent variable, by itself, is assumed to impact the status or nature of the dependent variable. Therefore, the former variable is the assumed “causative” variable, and the latter is the assumed “response” variable.

Some landfill site characteristics assumed to be independent, however, are related to other landfill site characteristics, so are not truly “independent.” For example, an analysis of the independent variable *Owner Type* and the dependent variable “In Corrective Action” examines the hypothesis that the owner type may influence whether a landfill is in the category “In Corrective Action.” The initial statistical analysis result indicated that privately owned landfill sites are more likely than public sites to be in corrective action. However, further analysis showed that *Social Setting* is related to *Owner*

Type, as privately owned landfills are more likely than publicly owned landfills to be in non-rural areas. Thus, *Social Setting* may also have a bearing on the corrective action status of landfills. (To view the results for this analysis, including graphical summaries, see Appendix C-1.)

Generally in cases where there is a relationship between the site characteristics, such as this one, the available data and scope of these statistical analyses are insufficient to clearly determine which site variable is most responsible for correlation with the dependent variable.

4 Results of Environmental Performance Analyses by Individual Landfill Site Characteristics

This section presents a summary of environmental performance results by individual landfill site characteristics from various quantitative and statistical analyses (as discussed in Sections 2 and 3). Each landfill site characteristic was evaluated against the following environmental performance variables:

1. In Corrective Action
2. Has Gas Inspection Report
3. Has Gas Enforcement Action[†]
4. Has Surface Water Action

In addition to these four environmental performance variables, the statistical analyses also evaluated each landfill site characteristic against the “Has Air Quality Violation” environmental performance variable.

As discussed in Section 3.3.2, the environmental performance variable “Has Air Quality Violation” is reported only for the landfills within the SCAQMD and the BAAQMD. Therefore, the statistical analyses for this variable were conducted only on a two-district subset of the full population. The remaining four environmental performance variables were quantitatively evaluated on a statewide basis.

For 11 of the 13 landfill site characteristics, environmental performance results are presented from two levels of analysis of the Task 2 database inventory: (1) a quantitative review presented in this section and (2) a statistical review with results and graphical summaries in Appendices B-2 through C-2. For the two remaining landfill site characteristics (*Site Status* and *Fill Method*), results are presented only for the quantitative review of the Task 2 database.

4.1 Owner Type

Table 4A summarizes environmental performance results for the quantitative review of data in the inventory for the *Owner Type* landfill site characteristic and the four statewide environmental performance variables.

[†] Any landfill in the “Has Gas Enforcement Action” category is also in the “Has Gas Inspection Report” category due to the fact that the latter variable represents the preliminary step an EA would take before initiating an enforcement action.

Table 4-A: Summary of Environmental Performance Data for Owner Type

Owner Type Categories	Number and (Percent) of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and (percent) of landfills per category	Has Gas Inspection Report Number and (percent) of landfills per category	Has Gas Enforcement Action Number and (percent) of landfills per category	Has Surface Water Action Number and (percent) of landfills per category
Private	56 (25%)	Yes – 26 (46.4%) No – 30 (53.6%)	Yes – 31 (55.4%) No – 25 (44.6%)	Yes – 10 (17.9%) No – 46 (82.1%)	Yes- 16 (28.6%) No – 40 (71.4%)
Public	168 (75%)	Yes – 45 (26.8%) No – 123 (73.2%)	Yes – 81 (48.2%) No – 87 (51.8%)	Yes – 21 (12.5%) No – 147 (87.5%)	Yes – 33 (19.6%) No – 135 (80.4%)

4.1.1 Observations From Quantitative Data Review (Table 4-A)

Privately owned landfills have a higher relative occurrence in each of the four environmental performance variables above than do publicly owned landfills. The significance of this apparent relationship is discussed in the following section.

4.1.2 Findings From Statistical Analysis

A statistical analysis of data pertaining to owner type resulted in the following findings with regard to correlations that could be drawn between the *Owner Type* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Statistical analysis of data in the inventory shows that private sites are 2.37 times more likely to be in the category “In Corrective Action” than public sites. However, the correlation between private ownership and “In Corrective Action” may to varying degrees be due to the relationship between *Owner Type* and *Social Setting*, *Landfill Gas Collection System*, *Liner Type*, *Landfill Size (Permitted Disposal Area)*, or *Average Annual Precipitation*. The latter five variables also exhibited a positive correlation with the category “In Corrective Action” and with *Owner Type*.

To better understand if the variable *Owner Type* is independent in its correlation with corrective action, the potential correlation of *Owner Type* to other independent variables was examined. (For further discussion on the relationship between assumed independent variables and dependent variables, see Section 3.4.) The results for these analyses, including graphical summaries, are provided in Appendix C-1. Based on these further analyses, the following finding can be made: **Owner type is not necessarily an indicator of environmental performance.**

The assumption in the analyses that *Owner Type* is an independent variable assumes that private and public owners are equally likely to own an urban site or a rural site. Further analysis shows that urban sites are more likely to be privately owned and rural sites publicly owned, as described below:

- Private owners are freer to choose sites than public owners. Looking to reduce costs and increase income, private owners are likely to choose sites that provide the most return for the capital investment. These would likely be urban sites, which, because of their size, would generally have greater waste streams than rural sites. On the other hand, public owners may have to provide a suitable disposal site as a public service, regardless of return on investment.
- Urban sites are also more likely to be significantly larger than rural sites and more likely to be partially unlined, increasing the potential for being in the category “In Corrective Action.”

No additional statistically significant correlations resulted from the analysis of *Owner Type* with the other four environmental performance variables.

4.2 Landfill Age

Table 4B provides a summary of environmental performance results for the quantitative review of the database for the *Landfill Age* site characteristic and the four statewide environmental performance variables.

Table 4-B: Summary of Environmental Performance Data for *Landfill Age*

<i>Landfill Age</i> Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and (percent) of landfills per category	Has Gas Inspection Report Number and (percent) of landfills per category	Has Gas Enforcement Action Number and (percent) of landfills per category	Has Surface Water Action Number and (percent) of landfills per category
1910s	1 (0.4%)	Yes – 1 (100%) No - 0 (0%)	Yes – 1 (100%) No - 0 (0%)	Yes – 0 (0%) No - 1 (100%)	Yes – 0 (0%) No - 1 (100%)
1920s	3 (1.3%)	Yes – 1 (33%) No - 2 (67%)	Yes – 2 (67%) No - 1 (33%)	Yes – 0 (0%) No - 3 (100%)	Yes – 1 (33%) No - 2 (67%)
1930s	6 (2.7%)	Yes – 3 (50%) No - 3 (50%)	Yes – 5 (83%) No - 1 (17%)	Yes – 2 (33%) No - 4 (67%)	Yes – 1 (17%) No - 5 (83%)

Landfill Age Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and (percent) of landfills per category	Has Gas Inspection Report Number and (percent) of landfills per category	Has Gas Enforcement Action Number and (percent) of landfills per category	Has Surface Water Action Number and (percent) of landfills per category
1940s	12 (5.4%)	Yes – 3 (25%) No - 9 (75%)	Yes – 10 (83.3%) No - 2 (16.7%)	Yes – 1 (8.3%) No - 11 (91.7%)	Yes – 1 (8.3%) No - 11 (91.7%)
1950s	32 (14.3%)	Yes – 11 (34.4%) No - 21 (65.6%)	Yes – 19 (59.4%) No – 13 (40.6%)	Yes – 5 (15.6%) No – 27 (84.4)	Yes – 6 (18.8%) No – 26 (81.2%)
1960s	68 (30.4%)	Yes – 27 (39.9%) No - 41 (60.3%)	Yes – 34 (50%) No - 34 (50%)	Yes – 9 (13.2%) No - 59 (86.8%)	Yes – 17 (25%) No - 51 (75%)
1970s	81 (36.2%)	Yes –21 (25.9%) No - 60 (74.1%)	Yes – 36 (44.5%) No - 45 (55.5%)	Yes – 13 (16.0%) No – 68 (84.0%)	Yes – 18 (22.2%) No – 63 (77.8%)
1980s	13 (5.8%)	Yes –1 (7.7%) No - 12 (92.3%)	Yes –3 (23.1%) No - 10 (76.9%)	Yes –1 (7.7%) No - 12 (92.3%)	Yes –2 (15.4%) No - 11 (84.6%)
1990s	8 (3.6%)	Yes –3 (37.5%) No - 5 (62.5%)	Yes –2 (25%) No - 6 (75%)	Yes –0 (0%) No - 8 (100%)	Yes –3 (37.5%) No - 5 (62.5%)

4.2.1 Observations From Quantitative Data Review (Table 4-B)

The following observations were made upon review of Table 4-B:

From the data, it appears that the “Has Gas Enforcement” variable is more common in landfills starting in the 1930s, and 1950s through 1970s than either older or younger landfills.

“In Corrective Action” has the highest relative occurrence in very old landfills (from the 1910s). However, with a sample size of only 1, this quantitative conclusion is likely not significant.

The statistical significance of these apparent relationships is discussed in the following section.

4.2.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to landfill age resulted in the following findings with regard to correlations that could be drawn between the *Landfill Age* site characteristic and the environmental performance variables. The age categories were grouped in 20-year increments to increase the number of sites in each sample. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

Has Gas Inspection Report

The age of a site appears to have a strong influence on whether a site is in the category of “Has Gas Inspection Report.” The results for three age-based independent variables (21 to 40 years of age, 41 to 60 years of age, and greater than 60 years of age), which can be seen in Appendix B-3, indicate that older sites are more likely to be in the category “Has Gas Inspection Report.” In fact, landfills older than 60 years are 4.36 times more likely to be in the category “Has Gas Inspection Report” than other sites. No correlation was found for landfills 20 years of age or less.

No other statistically significant correlations resulted from the analysis of *Landfill Age* with respect to the environmental performance variables.

4.3 Landfill Size (*Permitted Disposal Area*)

Table 4-C provides a summary of environmental performance results for the quantitative review of the database for the *Landfill Size* site characteristic and four statewide environmental performance variables. As part of this study, data measuring landfill size were gathered for the variables *Permitted Disposal Area*, *Permitted Disposal Volume*, *Permitted Maximum Daily Tonnage*, and *Estimated Remaining Capacity*. Generally, *Permitted Disposal Area*, *Permitted Disposal Volume*, and *Maximum Daily Tonnage* are very closely related to each other. Therefore, any single measure can be used to assess correlations with the environmental response variables. For purposes of the study, *Permitted Disposal Area* was selected for analysis. Furthermore, because *Remaining Capacity* conceptually has no physical bearing on the current performance, it was not evaluated.

Table 4-C: Summary of Environmental Performance Data for *Landfill Size (Permitted Disposal Area)*

<i>Landfill Size (Permitted Disposal Area)</i> Categories (acres)	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and (percent) of landfills per category	Number and (percent) of landfills per category	Number and (percent) of landfills per category	Number and (percent) of landfills per category
0 – 1.9	6 (2.7%)	Yes – 0 (0%) No - 6 (100%)	Yes – 0 (0%) No - 6 (100%)	Yes – 0 (0%) No - 6 (100%)	Yes – 0 (0%) No - 6 (100%)

Landfill Size (Permitted Disposal Area) Categories (acres)	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and (percent) of landfills per category	Has Gas Inspection Report Number and (percent) of landfills per category	Has Gas Enforcement Action Number and (percent) of landfills per category	Has Surface Water Action Number and (percent) of landfills per category
2 – 9.9	22 (9.8%)	Yes – 4 (18.2%) No – 18 (81.8%)	Yes – 6 (27.3%) No – 16 (72.7%)	Yes – 2 (9.1%) No – 20 (90.9%)	Yes – 3 (13.6%) No – 19 (86.4%)
10 – 19.9	23 (10.3%)	Yes – 3 (13.0%) No – 20 (87.0%)	Yes – 9 (39.1%) No – 14 (60.9%)	Yes – 2 (8.7%) No – 21 (91.3%)	Yes – 4 (17.4%) No – 19 (82.6%)
20 – 39.9	36 (16.1%)	Yes – 9 (25.0%) No – 27 (75.0%)	Yes – 15 (41.7%) No – 21 (48.3%)	Yes – 2 (5.6%) No – 34 (94.4%)	Yes – 7 (19.4%) No – 29 (80.6%)
40 – 79.9	49 (21.9%)	Yes – 20 (40.8%) No – 29 (59.2%)	Yes – 27 (55.1%) No – 22 (44.9%)	Yes – 10 (20.4%) No – 39 (79.6%)	Yes – 13 (26.5%) No – 36 (73.5%)
80 – 159.9	40 (17.9%)	Yes – 13 (32.5%) No – 27 (67.5%)	Yes – 25 (62.5%) No – 15 (37.5%)	Yes – 6 (15.0%) No – 34 (85.0%)	Yes – 7 (17.5%) No – 33 (82.5%)
160 – 319.9	34 (15.2%)	Yes – 14 (41.2%) No – 20 (58.8%)	Yes – 21 (61.8%) No – 13 (38.2%)	Yes – 5 (14.7%) No – 29 (85.3%)	Yes – 12 (35.3%) No – 22 (64.7%)
320 – 639.9	11 (4.9 %)	Yes – 7 (63.7%) No – 4 (36.3%)	Yes – 7 (63.7%) No – 4 (36.3%)	Yes – 3 (27.3%) No – 8 (72.7%)	Yes – 2 (18.2%) No – 9 (81.8%)
640 or more	3 (1.3%)	Yes – 1 (33.3%) No – 2 (66.7%)	Yes – 2 (66.7%) No – 1 (33.3%)	Yes – 1 (33.3%) No – 2 (66.7%)	Yes – 1 (33.3%) No – 2 (66.7%)

4.3.1 Observations From Quantitative Data Review (Table 4-C)

The data in Table 4-C suggest that landfills that are less than 40 acres in permitted disposal area have a lower occurrence of each environmental performance variable. Small landfills that are less than 2 acres in permitted disposal area appear to have the lowest occurrence of each environmental performance variable.

The statistical significance of these apparent relationships is discussed in the following section.

4.3.2 Findings From Statistical Analysis

A statistical analysis of data pertaining to landfill size resulted in the following findings with regard to correlations that could be drawn between the *Landfill Size* site characteristic (pertaining to permitted disposal area) and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

The permitted disposal area is significantly greater at sites that are “In Corrective Action”.

Has Gas Inspection Report

The permitted disposal area is significantly greater at sites that are in the category “Has Gas Inspection Report.”

Has Air Quality Violation

The permitted disposal area is significantly greater at SCAQMD/BAAQMD sites that are in the category “Has Air Quality Violation.” However, this finding could be due to the presence of a landfill gas collection system. When the total non-methane organic compound (NMOC) surface emissions exceed 50 million grams per year from the landfill, a landfill gas collection system may be required. Sites with landfill gas collection systems have more potential for air quality violations, since these sites have more equipment that is monitored by air districts, increasing the potential for violations. Therefore, the variables *Landfill Size (Permitted Disposal Area)* and *Landfill Gas Collection System* are not likely independent of each other. For further discussion on the relationship between assumed independent variables and dependent variables, see Section 3.4.

No other statistically significant correlations resulted from the analysis of *Landfill Size (Permitted Disposal Area)* with respect to the other environmental performance variables.

4.4 Social Setting

Table 4-D provides a summary of environmental performance results for the quantitative review of the database for the *Social Setting* landfill site characteristic and the four statewide environmental performance variables.

Table 4-D: Summary of Environmental Performance Data for *Social Setting*

<i>Social Setting</i> Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and (percent) of landfills per category	Has Gas Inspection Report Number and (percent) of landfills per category	Has Gas Enforcement Action Number and (percent) of landfills per category	Has Surface Water Action Number and (percent) of landfills per category
Urban	71 (31.7%)	Yes – 37 (52.1%) No – 34 (47.9%)	Yes – 49 (69.0%) No – 22 (31.0%)	Yes – 16 (22.5%) No – 55 (77.5%)	Yes – 20 (28.2%) No – 51 (71.8%)
Suburban	14 (6.3%)	Yes – 3 (21.4%) No – 11 (78.6%)	Yes – 6 (42.9%) No – 8 (57.1%)	Yes – 0 (0%) No – 14 (100%)	Yes – 1 (7.1%) No – 13 (92.9%)
Rural	139 (62.1%)	Yes – 31 (22.3%) No – 108 (77.7%)	Yes – 57 (41.0%) No – 82 (59.0%)	Yes – 15 (10.8%) No – 124 (89.2%)	Yes – 28 (20.9%) No – 111 (79.1%)

4.4.1 Observations From Quantitative Data Review (Table 4-D)

Urban landfills have a higher relative occurrence of each of the four environmental performance variables. Suburban landfills have the lowest relative occurrence of gas enforcement actions and surface water actions.

The statistical significance of these apparent relationships is discussed in the following section.

4.4.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to social setting resulted in the following findings with regard to correlations that could be drawn between the *Social Setting* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Urban sites are 3.97 times more likely to be in the category “In Corrective Action” than rural sites. No other social settings increase or decrease the likelihood that a site is in corrective action.

Has Gas Inspection Report

Urban sites are approximately 3.2 times more likely to be in the category “Has Gas Inspection Report” than rural sites. The Suburban social setting does not increase or decrease the likelihood that a site is in the category “Has Gas Inspection Report.”

Has Gas Enforcement Action

Urban sites are approximately 2.4 times more likely to be in the category “Has Gas Enforcement Action” than rural sites. None of the suburban sites are in the category “Has Gas Enforcement Action.”

No other statistically significant additional correlations resulted from the analysis of *Social Setting* with respect to the other environmental performance variables.

4.5 Physical Setting

Table 4-E provides a summary of environmental performance results for the quantitative review of the database for the *Physical Setting* landfill site characteristic and the four statewide environmental performance variables.

Table 4-E: Summary of Environmental Performance Data for *Physical Setting*

<i>Physical Setting</i> Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
Coastal	17 (7.6%)	Yes – 8 (47.1%) No – 9 (52.9%)	Yes – 10 (58.8%) No – 7 (41.2%)	Yes – 2 (11.8%) No – 15 (88.2%)	Yes – 7 (41.2%) No – 10 (58.8%)
Estuarine	8 (3.6%)	Yes – 2 (25.0%) No – 6 (75.0%)	Yes – 6 (75.0%) No – 2 (25.0%)	Yes – 2 (25.0%) No – 6 (75.0%)	Yes – 3 (37.5%) No – 5 (62.5%)
Desert	58 (25.9%)	Yes – 9 (15.5%) No – 49 (84.5%)	Yes – 21 (36.2%) No – 37 (63.8%)	Yes – 2 (3.4%) No – 56 (96.6%)	Yes – 5 (8.6%) No – 53 (91.4%)
Alpine	13 (5.8%)	Yes – 3 (23.1%) No – 10 (76.9%)	Yes – 2 (15.4%) No – 11 (84.6%)	Yes – 2 (15.4%) No – 11 (84.6%)	Yes – 0 (0%) No – 13 (100%)

<i>Physical Setting Categories</i>	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
High Desert	9 (4.0%)	Yes – 1 (11.1%) No – 8 (88.9%)	Yes – 5 (55.6%) No – 4 (44.4%)	Yes – 0 (0%) No – 9 (100%)	Yes – 0 (0%) No – 9 (100%)
Inland	119 (53.1%)	Yes – 48 (40.3%) No – 71 (59.7%)	Yes – 68 (57.1%) No – 51 (43.9%)	Yes – 23 (19.3%) No – 96 (80.7%)	Yes – 34 (28.6%) No – 85 (71.4%)

4.5.1 Observations From Quantitative Data Review (Table 4-E)

Landfills in alpine and high desert settings have a very low occurrence of surface water action. This may be due, in part, to the precipitation accumulating as snowfall rather than rain.

The statistical significance of the data trends are discussed in the following section.

4.5.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to physical setting resulted in the following findings with regard to correlations that could be drawn between the *Physical Setting* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Drier sites (those located in desert settings and/or that experience relatively low average annual precipitation) are 3.68 times less likely to be in the category “In Corrective Action” than inland sites. No other physical settings increase or decrease the likelihood that a site is in the category “In Corrective Action.”

As noted in Section 2.2.7, desert sites are classified as such in the database based on the amount of precipitation received per year. Therefore, the variable *Physical Setting* is not independent. It is likely that correlations between *Physical Setting* and “In Corrective Action” are related to the category *Average Annual Precipitation*. For further discussion on the relationship between assumed independent variables and dependent variables, see Section 3.4.

Has Gas Inspection Report

Desert sites are approximately 2.3 times less likely to be in the category “Has Gas Inspection Report” than inland sites. Alpine sites are approximately 7.3 times less likely than inland sites to be in the category “Has Gas Inspection Report.” No other physical settings increase or decrease the likelihood that a site is in the “Has Gas Inspection Report” category.

As stated under “In Corrective Action,” correlations between Physical Setting and “In Corrective Action” are likely related to the variable Average Annual Precipitation. However, the correlation between Physical Setting and “Has Gas Inspection Report” may have no relationship to Average Annual Precipitation, as precipitation does not appear to have a significant influence on whether a site is in the category “Has Gas Inspection Report.”

Has Gas Enforcement Action

Desert sites are approximately 6.7 times less likely to be in the category “Has Gas Enforcement Action,” than inland sites. None of the high desert sites were in the category “Has Gas Enforcement Action. No other physical settings increase or decrease the likelihood that a site “Has Gas Enforcement Action.”

Has Surface Water Action

Desert sites are approximately 4.2 times less likely to be in the “Has Surface Water Action” category than inland sites. Analysis results appear to support the assumption that site status in regard to the category “Has Surface Water Action” is influenced by amount of precipitation.

No other statistically significant correlations resulted from the analysis of *Physical Setting* with respect to the other environmental performance variables.

4.6 Underlying Geologic Material

Table 4-F provides a summary of environmental performance results for the quantitative review of the database for the *Underlying Geologic Material* landfill site characteristic and the four statewide environmental performance variables.

Table 4-F: Summary of Environmental Performance Data for *Underlying Geologic Material*

<i>Underlying Geologic Material</i> Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category
Silts/Clays	62 (27.7%)	Yes – 18 (29.0%) No – 44 (71.0%)	Yes – 31 (50.0%) No – 31 (50.0%)	Yes – 12 (19.4%) No – 50 (80.6%)	Yes – 20 (32.3%) No – 42 (67.7%)
Sand and/or Gravel	95 (42.4%)	Yes – 35 (36.8%) No – 60 (63.2%)	Yes – 43 (45.3%) No – 52 (54.7%)	Yes – 11 (11.6%) No – 84 (88.4%)	Yes – 13 (13.7%) No – 82 (86.3%)
Sedimentary Rock	51 (22.8%)	Yes – 14 (27.5%) No – 37 (72.5%)	Yes – 31 (60.8%) No – 20 (39.2%)	Yes – 8 (15.7%) No – 43 (84.3%)	Yes – 14 (27.5%) No – 37 (72.5%)
Igneous Rock	16 (7.1%)	Yes – 4 (25.0%) No – 12 (75.0%)	Yes – 7 (43.8%) No – 9 (56.2%)	Yes – 0 (0%) No – 16 (100%)	Yes – 2 (12.5%) No – 14 (87.5%)

4.6.1 Observations From Quantitative Data Review (Table 4-F)

Landfills cited over igneous rock have a low occurrence of gas enforcement actions.

4.6.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to underlying geologic material resulted in the following findings with regard to correlations that could be drawn between the *Underlying Geologic Material* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

Has Gas Inspection Report

No correlation resulted from the analysis at a 95 percent significance level. However, at a 90 percent significance level, results indicate that a sedimentary rock site is approximately 1.9 times more likely than a sand and/or gravel site to be in the category “Has Gas Inspection Report.”

Has Gas Enforcement Action

None of the igneous rock sites were in the category “Has Gas Enforcement Action.” No other underlying geologic materials increase or decrease the likelihood that a site is in the category “Has Gas Enforcement Action.”

Has Surface Water Action

Sites constructed on sedimentary rock are 2.4 times more likely to be in the category “Has Surface Water Action” than sand and/or gravel sites. Sites constructed on silts/clays are 3.0 times more likely to be in the category “Has Surface Water Action” than sand and/or gravel sites.

No other statistically significant correlations resulted from the analysis of *Underlying Geologic Material* with respect to the other environmental performance variables.

4.7 Minimum Depth to Underlying Groundwater

Table 4-G provides a summary of environmental performance results for the quantitative review of the database for the *Minimum Depth to Underlying Groundwater* landfill site characteristic and the four statewide environmental performance variables.

Table 4-G: Summary of Environmental Performance Data for *Minimum Depth to Underlying Groundwater*

<i>Minimum Depth to Underlying Groundwater</i> Categories (feet)	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category
0 – 4.9	37 (16.5%)	Yes –13 (35.1%) No – 24 (64.9%)	Yes –19 (51.4%) No – 18 (48.6%)	Yes –2 (5.4%) No – 35 (94.6%)	Yes –12 (32.4%) No – 25 (67.6%)
5 – 9.9	21 (9.4%)	Yes –8 (38.1%) No – 13 (61.9%)	Yes –10 (47.6%) No – 11 (52.4%)	Yes – 6 (28.6%) No – 15 (71.4%)	Yes –4 (19.0%) No – 17 (81.0%)
10 – 49	62 (27.7%)	Yes –24 (38.7%) No – 38 (61.3%)	Yes –30 (48.4%) No – 32 (51.6%)	Yes –10 (16.1%) No – 52 (83.9%)	Yes –18 (29.0%) No – 44 (71.0%)

<i>Minimum Depth to Underlying Groundwater Categories (feet)</i>	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
50 – 99	42 (18.8%)	Yes –12 (28.6%) No – 30 (71.4%)	Yes –28 (66.7%) No – 14 (33.3%)	Yes –5 (11.9%) No – 37 (88.1%)	Yes –6 (14.3%) No – 36 (85.7%)
100 – 199	30 (13.4%)	Yes – 6 (20.0%) No – 24 (80.0%)	Yes –12 (40.0%) No – 18 (60.0%)	Yes –5 (16.7%) No – 25 (83.3%)	Yes –5 (16.7%) No – 25 (83.3%)
200 – 499	23 (10.3%)	Yes –5 (21.7%) No – 18 (78.2%)	Yes –9 (39.1%) No – 14 (60.9%)	Yes –2 (8.7%) No – 21 (91.3%)	Yes –1 (4.3%) No – 22 (95.7%)
500 or more	9 (4.0%)	Yes –3 (33.3%) No – 6 (66.7%)	Yes – 4 (44.4%) No – 5 (55.6%)	Yes –1 (11.1%) No – 8 (88.9%)	Yes –3 (33.3%) No – 6 (66.7%)

4.7.1 Observations From Quantitative Data Review (Table 4-G)

The data presented above quantitatively do not appear to suggest any trends between the two variables.

4.7.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to minimum depth to underlying groundwater in Table 4G resulted in the following findings with regard to correlations that could be drawn between the *Minimum Depth to Underlying Groundwater* site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

Has Surface Water Action

The minimum depth to underlying groundwater is significantly less at those sites in the category “Has Surface Water Action.” In addition to higher groundwater levels, an analysis of sites in the category “Has Surface Water Action” also shows these sites to have significantly greater precipitation.

No other statistically significant correlations resulted from the analysis of *Minimum Depth to Underlying Groundwater* with respect to the other environmental performance variables.

4.8 Average Annual Precipitation

Table 4-H provides a summary of environmental performance results for the quantitative review of the database for the *Average Annual Precipitation* landfill site characteristic and the four statewide environmental performance variables.

Table 4-H: Summary of Environmental Performance Data for Average Annual Precipitation

Average Annual Precipitation Categories (inches)	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
0 – 9.9	71 (31.7%)	Yes –14 (19.7%) No – 57 (80.3%)	Yes –26 (36.6%) No – 45 (63.4%)	Yes –2 (2.8%) No – 69 (97.2%)	Yes – 4 (5.6%) No – 67 (94.4%)
10 – 19.9	96 (42.9%)	Yes –37 (38.5%) No – 59 (61.5%)	Yes –59 (61.5%) No – 37 (38.5%)	Yes – 23 (24.0%) No – 73 (76.0%)	Yes –28 (29.2%) No – 68 (70.8%)
20 – 29.9	30 (13.4%)	Yes –13 (43.3%) No – 17 (56.7%)	Yes –21 (70.0%) No – 9 (30.0%)	Yes –6 (25.0%) No – 24 (75.0%)	Yes –13 (43.3%) No – 17 (56.7%)
30 – 39.9	15 (6.7%)	Yes –5 (33.3%) No – 10 (66.7%)	Yes –3 (20.0%) No – 12 (80.0%)	Yes –0 (0.0%) No – 15 (100%)	Yes –5 (33.3%) No – 10 (66.7%)
40 – 49.9	3 (1.3%)	Yes –1 (33.3%) No – 2 (66.7%)	Yes –1 (33.3%) No – 2 (66.7%)	Yes –0 (0.0%) No – 3 (100.0%)	Yes –2 (66.7%) No – 1 (33.7%)
50 – 59.9	6 (2.7%)	Yes – 0 (0.0%) No – 6 (100.0%)	Yes –1 (16.7%) No – 5 (83.3%)	Yes –0 (0.0%) No – 6 (100.0%)	Yes –2 (33.3%) No – 4 (66.7%)
60 – 69.9	2 (0.9%)	Yes –0 (0.0%) No – 2 (100.0%)	Yes –0 (0.0%) No – 2 (100.0%)	Yes –0 (0.0%) No – 2 (100.0%)	Yes –1 (50.0%) No – 1 (50.0%)

Average Annual Precipitation Categories (inches)	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category
70 – 79.9	1 (0.4%)	Yes –1 (100.0%) No – 0 (0.0%)	Yes –1 (100.0%) No – 0 (0.0%)	Yes –0 (0.0%) No – 1 (100%)	Yes –1 (100.0%) No – 0 (0.0%)

4.8.1 Observations From Quantitative Data Review (Table 4-H)

Gas inspection reports are more concentrated in sites with average annual precipitation of less than 30 inches. Gas enforcement actions are more concentrated in sites with average annual precipitation ranging from 10 inches to 30 inches.

The statistical significance of these apparent relationships and others is discussed in the following section.

4.8.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to average annual precipitation resulted in the following findings with regard to correlations that could be drawn between the *Average Annual Precipitation* site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Annual precipitation depths are significantly greater at sites that are in the category “In Corrective Action.” Drier sites (those located in desert settings and/or that experience relatively low annual precipitation) are less likely to exhibit groundwater-related environmental indicators than wetter sites.

Has Surface Water Action

Average annual precipitation amounts are significantly greater at sites that are in the category “Has Surface Water Action.” Analysis results appear to support the assumption that whether a site is in the category “Has Surface Water Action” is influenced by the amount of precipitation. The data appears to support the conclusion that sites that have significantly greater precipitation are more likely to be both in the “In Corrective Action” and the “Has Surface Water Action” categories.

No other additional statistically significant correlations resulted from the analysis of *Average Annual Precipitation* with respect to the other environmental performance variables.

4.9 Liner Type

Table 4-I, below, provides a summary of environmental performance results for the quantitative review of the database for the *Liner Type* landfill site characteristic and the four statewide environmental performance variables.

Table 4-I: Summary of Environmental Performance Data for Landfill *Liner Type*

Liner Type Categories	Number and (Percent) of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category
Fully Subtitle D	4 (1.8%)	Yes – 1 (25.0%) No – 3 (75.0%)	Yes – 2 (50.0%) No – 2 (50.0%)	Yes – 0 (0.0%) No – 4 (100.0%)	Yes – 1 (25.0%) No – 3 (75.0%)
Fully Lined, Partially Non-Subtitle D	12 (5.4%)	Yes – 5 (41.7%) No – 7 (58.3%)	Yes – 7 (58.3%) No – 5 (41.7%)	Yes – 3 (25.0%) No – 9 (75.0%)	Yes – 2 (16.7%) No – 10 (83.4%)
Partially Unlined	70 (31.3%)	Yes – 32 (45.7%) No – 38 (54.3%)	Yes – 47 (67.1%) No – 23 (32.9%)	Yes – 15 (21.4%) No – 55 (78.6%)	Yes – 18 (25.7%) No – 52 (74.3%)
Fully Unlined	138 (61.6%)	Yes – 33 (23.9%) No – 105 (76.1%)	Yes – 56 (40.6%) No – 82 (59.4%)	Yes – 13 (9.4%) No – 125 (90.6%)	Yes – 28 (20.3%) No – 110 (79.7%)

4.9.1 Observations From Quantitative Data Review (Table 4-I)

Fully Subtitle-D lined sites and fully unlined sites have approximately the same relative occurrence of “In Corrective Action.” Partially unlined landfills have the highest occurrence in the categories “In Corrective Action” and “Gas Inspection Report.”

The statistical significance of these apparent relationships is discussed in the following section.

4.9.2 Findings From Statistical Analysis

A statistical analysis of the Liner Type data resulted in the following findings with regard to correlations that could be drawn between the *Liner Type* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Partially unlined sites are 2.75 times more likely to be in the category “In Corrective Action” than sites that are fully unlined. No other liner category increases or decreases the likelihood that a site is in the category “In Corrective Action” relative to fully unlined sites.

Further analysis of partially unlined sites indicates that one possible reason why these sites are more likely than fully unlined sites to be in the category “In Corrective Action” is that they tend to be significantly larger. This suggests that the *Liner Type* variable may not be independent of the *Landfill Size (Permitted Disposal Area)* variable. For further discussion on the relationship between assumed independent variables and dependent variables, see Section 3.4.

An analysis of possible dependence between *Liner Type* and *Landfill Size (Permitted Disposal Area)* was conducted, looking specifically at the difference between partially unlined and fully unlined sites. The results, summarized in Appendix C-2, provide some support to the hypothesis that landfill size may influence whether certain liner types are more or less likely to be in non-compliance with environmental standards. One suggested explanation for this outcome is that partially unlined sites tend to be large and relatively complex, thereby increasing the likelihood of non-compliance with certain standards.

Has Gas Inspection Report

Partially unlined sites are 3.1 times more likely to be in the category “Has Gas Inspection Report” than sites that are fully unlined. No other liner category increases or decreases the likelihood that a site is in the category “Has Gas Inspection Report” relative to fully unlined sites.

As discussed above under “In Corrective Action,” it is possible that the *Liner Type* variable is not completely independent of the *Landfill Size (Permitted Disposal Area)* variable. Partially unlined sites tend to be relatively large, complex sites, thereby potentially increasing the likelihood that they will be in the category “Has Gas Inspection Report.”

Has Gas Enforcement Action

Partially unlined sites are 2.7 times more likely to be in the category “Has Gas Enforcement Action” than sites that are fully unlined. No other liner category increases or decreases the likelihood that a site is in the category “Has Gas Inspection Report” relative to fully unlined sites.

As discussed above under “In Corrective Action,” partially unlined sites tend to be relatively large, complex sites, thereby potentially increasing the likelihood that they are in the “Has Gas Enforcement Action” category. It is possible that the *Liner Type* variable may not be completely independent of the *Landfill Size (Permitted Disposal Area)* variable.

No other statistically significant correlations resulted from the analysis of *Liner Type* with respect to the other environmental performance variables.

4.10 Final Cover Type

Table 4-J provides a summary of environmental performance results for the quantitative review of the database for the *Final Cover Type* landfill site characteristic and the four statewide environmental performance variables.

Table 4-J: Summary of Environmental Performance Data for *Final Cover Type*

Final Cover Type Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action	Has Gas Inspection Report	Has Gas Enforcement Action	Has Surface Water Action
		Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category	Number and percent of landfills per category
Fully Covered	48 (21.4%)	Yes – 17 (35.4%)	Yes – 20 (41.7%)	Yes – 1 (2.1%)	Yes – 6 (12.5%)
		No – 31 (64.6%)	No – 28 (59.3%)	No – 47 (97.9%)	No – 42 (87.5%)
Partially Covered	30 (13.4%)	Yes – 13 (43.3%)	Yes – 16 (53.3%)	Yes – 11 (36.7%)	Yes – 10 (33.3%)
		No – 17 (56.7%)	No – 14 (46.7%)	No – 19 (63.3%)	No – 20 (66.7%)
Fully Uncovered	146 (65.2%)	Yes – 41 (28.0%)	Yes – 76 (52.1%)	Yes – 19 (13.0%)	Yes – 33 (22.6%)
		No – 105 (72.0%)	No – 70 (47.9%)	No – 127 (87.0%)	No – 113 (77.4%)

4.10.1 Observations From Quantitative Data Review (Table 4-J)

Partially covered landfills have the highest relative occurrence of each of the four environmental performance variables. Fully covered landfills have the lowest occurrence of the “Has Gas Enforcement” variable.

The statistical significance of these apparent relationships is discussed in the following section.

4.10.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to final cover type resulted in the following findings with regard to correlations that could be drawn between the *Final Cover Type* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

Has Gas Enforcement Action

Partially covered sites are 4.6 times more likely to be in the category “Has Gas Enforcement Action” than fully uncovered sites. No correlation resulted from the analysis of fully covered and fully uncovered sites at a 95 percent significance level. However, at a 90 percent level of significance,

results indicate that a fully covered site is approximately 7.3 times less likely that a fully uncovered site to be in the “Has Gas Enforcement Action” category.

As with partially unlined sites, partially uncovered sites tend to be relatively large and complex. This may explain, in part, why the results indicate that partially covered sites are more likely to be in the category “Has Gas Enforcement Action” than fully uncovered sites.

No other statistically significant correlations resulted from the analysis of *Cover Type* with respect to the other environmental performance variables.

4.11 Landfill Gas Collection System

Table 4-K provides a summary of environmental performance results for the quantitative review of the database for the *Landfill Gas Collection System* landfill site characteristic and the four statewide environmental performance variables.

Table 4-K: Summary of Environmental Performance Data for *Landfill Gas Collection System*

Landfill Gas Collection System Categories	Number and Percent of Landfills in Study	Environmental Protection Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
Has System	103 (46.0%)	Yes – 52 (50.5%)	Yes – 70 (68.0%)	Yes – 22 (21.4%)	Yes – 25 (24.3%)
		No – 51 (49.5%)	No – 33 (32.0%)	No – 81 (78.5%)	No – 78 (75.7%)
Does Not Have System	121 (54.0%)	Yes – 19 (15.7%)	Yes – 42 (34.7%)	Yes – 9 (7.4%)	Yes – 24 (19.9%)
		No – 102 (84.3%)	No – 79 (65.3%)	No – 112 (92.6%)	No – 97 (80.1%)

4.11.1 Observations From Quantitative Data Review (Table 4K)

Landfills with landfill gas collection systems have a higher relative occurrence of each environmental response variables

The statistical significance of these apparent relationships is discussed in the following section.

4.11.2 Findings From Statistical Analysis

A statistical analysis of the data pertaining to landfill gas collections systems resulted in the following findings with regard to correlations that could be drawn between the *Landfill Gas Collection System* landfill site characteristic and the environmental performance variables. The results for this analysis, including graphical summaries, are provided in Appendices B-2 through B-5.

In Corrective Action

Sites that have landfill gas collection systems are 5.47 times more likely to be in the category “In Corrective Action” than sites that do not have landfill gas collection systems. This may be due to a variety of reasons:

- The presence of landfill gas collection systems may result in greater regulatory scrutiny, therefore increasing the likelihood that environmental concerns would be identified at a site.
- Landfill gas collection systems may be most prevalent at larger sites and those sites with previous environmental performance concerns. As discussed under the “In Corrective Action,” segment of Section 4.9.2, it is possible that the *Landfill Gas Collection System* variable may not be completely independent of the *Landfill Size (Permitted Disposal Area)* variable.
- The installation of a landfill gas collection system may be the result of corrective action to address other factors. For example, a gas collection system may be required if the total NMOC surface emissions exceed 50 million grams per year. In this case, it is the large size of the site (resulting in the total NMOC surface emissions), not the remedy to the situation (installation of a gas collection system) that causes the site to be in the category “In Corrective Action.”

Has Gas Inspection Report

Sites that have landfill gas collection systems are 3.1 times more likely to be in the category “Has Gas Inspection Report” than sites that do not have landfill gas collection systems.

As with the “In Corrective Action” category, a site that has a landfill gas collection system is more likely to be in the category “Has Gas Inspection Report” than one that does not have the gas collection system. The reason is because the presence of a landfill gas collection system (necessitated by the site’s greater size and resulting greater gas production) may lead to greater scrutiny by the regulators.

Has Gas Enforcement Action

Sites that have landfill gas collection systems are 3.4 times more likely to be in the category “Has Gas Enforcement Action” than sites that do not have landfill gas collection systems. See the discussion under “In Corrective Action” in this section for possible reasons.

Has Air Quality Violation

Sites equipped with landfill gas collection systems are 22.1 times more likely to be in the category “Has Air Quality Violation” than sites that do not have landfill gas collection systems.

An evaluation of the category “Has Air Quality Violations” indicates that significantly larger sites with landfill gas collection systems are more likely to be in this category. The reason for this is that sites receiving permits to have landfill gas collection systems have, as a result, equipment that air districts must monitor. More potential therefore exists for violations of the permitted conditions.

Based on the results presented above, the existence of a landfill gas collection system at a landfill is not necessarily an indicator of environmental performance.

The chronology of site history may lead to a more interesting finding—how the installation of a landfill gas collection system has affected environmental performance. Unfortunately, the “snapshot in time” approach to data collection used for the purposes of this report does not lend itself to answering this question.

No additional correlations resulted from the analysis of *Landfill Gas Collection System* with the other environmental performance variables.

4.12 Site Status

Table 4-L provides a summary of environmental performance results for the quantitative review of the database for the *Site Status* landfill site characteristic and the four statewide environmental performance variables.

Table 4-L: Summary of Environmental Performance Data for Site Status

Site Status Categories	Number and Percent of Landfills in Study	Environmental Performance Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
Active	128 (57.2%)	Yes – 32 (25.0%) No – 96 (75.0%)	Yes – 66 (51.6%) No – 62 (48.4%)	Yes – 22 (17.2%) No – 106 (82.8%)	Yes – 29 (22.7%) No – 99 (77.3%)
Inactive	34 (15.2%)	Yes – 11 (32.4%) No – 23 (67.6%)	Yes – 13 (38.2%) No – 21 (61.8%)	Yes – 2 (5.9%) No – 32 (94.1%)	Yes – 8 (23.5%) No – 26 (76.5%)
Closed	31 (13.8%)	Yes – 8 (25.8%) No – 23 (74.2%)	Yes – 11 (35.5%) No – 20 (64.5%)	Yes – 0 (0.0%) No – 31 (100.0%)	Yes – 1 (3.2%) No – 30 (96.8%)
Combination	31 (13.8%)	Yes – 20 (64.5%) No – 11 (35.5%)	Yes – 22 (71.0%) No – 9 (29.0%)	Yes – 7 (22.6%) No – 24 (77.3%)	Yes – 11 (35.5%) No – 20 (64.5%)

4.12.1 Observations From Quantitative Data Review (Table 4-L)

Closed landfills have the lowest relative occurrence of each of the environmental performance variables, with the exception of “In Corrective Action.” Combination sites have the highest relative occurrence of each of the environmental performance variables.

Combination sites, much like the partially covered sites, are more likely to be large and complex and lead to a greater occurrence of the environmental performance variables.

These apparent relationships are more likely a function of cover type than of site status. Closed sites, by definition, must have a final cover. Active sites must be partially uncovered in order to accept new waste. Therefore *Site Status* and *Cover Type* are clearly dependent. Because the *Cover Type* variable was already analyzed statistically, the *Site Status* variable was only evaluated quantitatively.

4.13 Fill Method

Table 4-M provides a summary of environmental performance results for the quantitative review of the database for the *Fill Method* landfill site characteristic and the four statewide environmental performance variables.

Table 4-M: Summary of Environmental Performance Data for *Fill Method*

Fill Method Categories	Number and Percent of Landfills in Study	Environmental Protection Variables			
		In Corrective Action Number and percent of landfills per category	Has Gas Inspection Report Number and percent of landfills per category	Has Gas Enforcement Action Number and percent of landfills per category	Has Surface Water Action Number and percent of landfills per category
Canyon Fill	41 (18.3%)	Yes – 19 (46.3%) No – 22 (53.7%)	Yes – 28 (68.8%) No – 13 (31.2%)	Yes – 5 (12.2%) No – 36 (87.8%)	Yes – 13 (31.7%) No – 28 (68.3%)
Area Fill	72 (32.1%)	Yes – 27 (37.5%) No – 45 (62.5%)	Yes – 40 (55.6%) No – 32 (44.4%)	Yes – 12 (16.7%) No – 60 (83.3%)	Yes – 19 (26.4%) No – 53 (73.6%)
Trench Fill	25 (11.2%)	Yes – 1 (4.0%) No – 24 (96.0%)	Yes – 7 (28.0%) No – 18 (72.0%)	Yes – 0 (0.0%) No – 25 (100.0%)	Yes – 0 (0.0%) No – 25 (100.0%)
Side-Hill Fill	5 (2.2%)	Yes – 1 (20.0%) No – 4 (80.0%)	Yes – 1 (20.0%) No – 4 (80.0%)	Yes – 0 (0.0%) No – 5 (100.0%)	Yes – 0 (0.0%) No – 5 (100.0%)
Pit/Quarry Fill	6 (2.7%)	Yes – 4 (66.7%) No – 2 (33.3%)	Yes – 2 (33.3%) No – 4 (66.7%)	Yes – 1 (16.7%) No – 5 (83.3%)	Yes – 0 (0.0%) No – 6 (100.0%)
Combination	75 (33.5%)	Yes – 19 (25.3%) No – 56 (74.7%)	Yes – 34 (45.3%) No – 41 (54.7%)	Yes – 13 (17.3%) No – 62 (82.7%)	Yes – 17 (22.7%) No – 58 (77.3%)

4.13.1 Observations From Quantitative Data Review (Table 4-M)

With the exception of “Has Gas Enforcement Action,” landfills with canyon fill methods have the highest relative occurrence of each environmental performance variable. Landfills with either the side hill fill or trench fill methods have the lowest relative occurrence of each environmental performance variable.

5 Results of Multiple-Variable Analyses

Section 5 summarizes the results of multiple-variable analyses of landfill site characteristics to provide the following:

- A profile of a “typical” California MSW landfill.
- A brief overview of the design and operational characteristics of urban, suburban, and rural landfills during the time of the study.
- A review of environmental performance for urban, suburban, and rural landfills by multiple site characteristics.
- A review of environmental performance for active, inactive, closed, and combination landfills by multiple site characteristics.

5.1 “Typical” California MSW Landfill

A profile of a “typical” California MSW landfill was derived by looking at the landfill site characteristics described in Section 2.2. To find the typical value for each site characteristic variable, each was statistically evaluated to find the mean, median, or mode.

In the case of a continuous variable with a relatively natural distribution (such as *Average Annual Precipitation*), “typical” was represented by the mean. In the case of a continuous variable with more of a logarithmic distribution (such as *Landfill Size [Permitted Disposal Area]*), “typical” was better represented by the median. In the case of a categorical variable (such as *Owner Type*), “typical” was better represented by the mode.

Based on the results of the statistical evaluation of the database, the typical MSW landfill in California can be described as shown in Table 5-A.

Table 5-A: Profile of a “Typical” California MSW Landfill

Landfill Site Characteristic	Typical Value
Owner Type	Publicly owned (county)
Site Status	Active
Social Setting	Rural
Fill Method	Area or combination
Landfill Size (Permitted Disposal Area)	55.5 acres
Permitted Disposal Volume	2.7 million cubic yards
Permitted Maximum Daily Tonnage	385 tons
Remaining Capacity	2.1 million cubic yards
Physical Setting	Inland
Underlying Geologic Material	Sand and/or gravel
Minimum Depth to Underlying Groundwater	34.5 feet
Average Annual Precipitation	16 inches
Liner Type	Fully unlined or partially unlined (active sites)
Cover Type	Fully uncovered
Landfill Gas Collection System	None

5.1.1 Observations From Data Review (Table 5-A)

The “typical” California MSW landfill is publicly owned, active, located inland, fully unlined or, in the case of active sites, partially unlined, fully uncovered, and has no gas collection system. The typical site is underlain by sand and/or gravel, has a minimum depth to underlying groundwater of 34.5 feet, and receives an average annual precipitation of 16 inches.

While there is no single site within this study that matches each of the above site characteristic values, the four sites that most closely match these typical values are:

- Amador County Landfill/Buena Vista Class II.
- Bass Hill Landfill.
- John Smith Road Class III Landfill.
- Ramona Landfill.

Because these four landfills come closest to representing a typical California MSW landfill, they have been recommended for the Phase II portion of the study, the assessment of regulatory effectiveness. The complete list of 40 landfills recommended for the Phase II portion of the study, including the four listed above, is presented in Section 7.

5.2 Summary and Comparison of Urban, Suburban, and Rural Landfills

5.2.1 Brief Overview of Urban, Suburban, and Rural Landfills By Eight Landfill Site Characteristics

To provide a brief overview of the design and operational characteristics of urban, suburban, and rural landfills during the time of the study, a simplified quantitative data review was completed on the following eight landfill site characteristics:

1. Owner Type
2. Landfill Age
3. Landfill Size (Permitted Disposal Area)
4. Physical Setting
5. Minimum Depth to Underlying Groundwater
6. Average Annual Precipitation
7. Liner Type
8. Landfill Gas Collection System

To streamline the effort, all of the variables used in the quantitative review were reduced to two mutually exclusive values. For example: urban, suburban, and rural landfills were divided into rural and non-rural landfills, with non-rural consisting of both urban and suburban sites; liner types were divided into lined and unlined; and average annual precipitation was divided into less than 14 inches and equal to or greater than 14 inches.

The complete results of this analysis are tabulated in Appendix D. From the results, the following statements are made:

1. There are more than twice as many publicly owned rural landfills as publicly owned non-rural landfills.

2. Most of the small landfills (defined here as less than 122 acres) are in rural social settings.
3. Most of the young landfills (defined here as younger than 35 years old) are in rural social settings. Older landfills (defined as 35 years old or greater) are nearly evenly divided between rural and non-rural social settings.
4. Most of the desert sites are in rural settings, whereas the inland sites are nearly evenly divided between rural and non-rural social settings.
5. Most of the landfills with deep groundwater (defined here as greater than or equal to 34.5 feet) are in rural social settings. Landfills with shallow groundwater (defined here as less than 34.5 feet) are nearly evenly divided between rural and non-rural social settings.
6. Landfills with relatively low average annual precipitation (less than 14 inches) trend to be rural. Landfills with 14 inches or more of average annual precipitation are nearly evenly divided between rural and non-rural social settings.
7. The majority of fully unlined sites are rural landfills.
8. Most landfills without gas collect systems are in rural social settings.

5.2.2 Summary of Environmental Performance of Urban, Suburban, and Rural Landfills by Five Landfill Site Characteristics

To better understand the environmental performance of urban, suburban, and rural landfills for the time of the study, a quantitative data review was completed on five landfill site characteristics. The quantitative review looked at all of the possible values for each of the site characteristics, unlike the more streamlined approach used in section 5.2.1. In reviewing the results, the reader is provided not only with information on environmental performance at these landfills, but also with a snapshot of the design and operational characteristics of these landfills for the five landfill site characteristics.

The results are summarized and compared against one another for the following five landfill site characteristics:

1. Site Status.
2. Landfill Size (Permitted Disposal Area).
3. Average Annual Precipitation.
4. Liner Type.
5. Landfill Gas Collection System.

Each site characteristic was evaluated against the following environmental performance variables:

1. In Corrective Action.
2. Has Gas Inspection Report.
3. Has Gas Enforcement Action.
4. Has Surface Water Action.

The data was taken from the Task 2 database and covers the time period from January 1998 through December 2001.

5.2.2.1 Results and Observations: Site Status

Table 5-B: Summary of Environmental Performance and Landfill Site Characteristic Data for Urban, Suburban, and Rural Landfills by *Site Status*

Landfill Site Characteristic				Environmental Performance Variables											
Site Status Categories	Number of Landfills in Study			In Corrective Action Number of landfills per category			Has Gas Inspection Report Number of landfills per category			Has Gas Enforcement Action Number of landfills per category			Has Surface Water Action Number of landfills per category		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
Active	38	9	81	16	2	14	24	4	38	12	0	10	12	1	16
Inactive	6	3	25	3	1	7	5	1	7	0	0	2	1	0	7
Closed	10	0	21	5	0	3	8	0	3	0	0	0	0	0	1
Combination	17	2	12	13	0	7	12	1	9	4	0	3	7	0	4

Observations From Quantitative Data Review (Table 5-B)

Urban, suburban, and rural landfills show similar relative distributions of active and closed site status. Inactive sites are relatively less common in urban social settings than in either suburban or rural social settings. Combination site status is more common among urban landfills than among either rural or suburban landfills.

Similar to the findings in Section 4.4.2, Table 5B shows that urban landfills have a higher relative occurrence of each environmental performance variable. When subdivided by site status, only the active sites show this same trend.

5.2.2.2 Results and Observations: Landfill Size (Permitted Disposal Area)

Table 5-C: Summary of Environmental Performance and Landfill Site Characteristic Data for Urban, Suburban, and Rural Landfills by *Landfill Size (Permitted Disposal Area)*

Landfill Site Characteristic				Environmental Performance Variables											
<i>Landfill Size (Permitted Disposal Area) Categories (acres)</i>	Number of Landfills in Study			In Corrective Action Number of landfills per category			Has Gas Inspection Report Number of landfills per category			Has Gas Enforcement Action Number of landfills per category			Has Surface Water Action Number of landfills per category		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0–9.9	0	0	28	0	0	4	0	0	6	0	0	2	0	0	3
10–99.9	25	8	89	12	2	20	18	4	38	5	0	11	6	1	18
100 or more	46	6	22	25	1	7	31	2	13	11	0	2	14	0	7

Observations From Quantitative Data Review (Table 5-C)

Urban sites are generally larger than rural sites. This is likely a function of the population each landfill serves. Less populated areas require less disposal capacity, whereas densely populated areas require greater disposal capacity. This observation confirms the interdependence of the *Permitted Disposal Area* and *Social Setting* site characteristics as discussed in Section 4.

Small, rural landfills of less than 10 acres in permitted disposal area have relatively low occurrences of each environmental performance variable. Conversely, large, urban landfills have relatively high occurrences of most environmental response variables.

5.2.2.3 Results and Observations: Average Annual Precipitation

Table 5-D: Summary of Environmental Performance and Landfill Site Characteristic Data for Urban, Suburban, and Rural Landfills by *Average Annual Precipitation*

Landfill Site Characteristic				Environmental Performance Variables											
<i>Average Annual Precipitation Categories (inches)</i>	Number of Landfills in Study			In Corrective Action Number of landfills per category			Has Gas Inspection Report Number of landfills per category			Has Gas Enforcement Action Number of landfills per category			Has Surface Water Action Number of landfills per category		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
0–8.9	5	7	57	2	2	8	3	2	20	0	0	1	0	0	4
9–24.9	60	7	54	33	1	15	43	4	30	16	0	14	17	1	13
25 or more	6	0	28	2	0	8	3	0	7	0	0	0	3	0	11

Observations From Quantitative Data Review (Table 5-D)

Urban landfills are more highly concentrated in areas with between 9 and 24.9 inches of average annual precipitation, whereas rural sites are more evenly divided among dry, moderate, and wet regions.

Urban landfills with between 9 and 24.9 inches of average annual precipitation have a higher relative occurrence of “In Corrective Action,” “Has Gas Inspection Report,” and “Has Gas Enforcement Action” than the other combinations of categories. Landfills with 25 inches or more average annual precipitation have the highest relative occurrence of “Has Surface Water Action” in both the urban and rural categories. This observation is similar to the findings presented in Section 4.8.2.

5.2.2.4 Results and Observations: Liner Type

Table 5-E: Summary of Environmental Performance and Landfill Site Characteristic Data for Urban, Suburban, and Rural Landfills by *Liner Type*

Landfill Site Characteristic				Environmental Performance Variables											
<i>Liner Type</i> Categories	Number of Landfills in Study			In Corrective Action Number of landfills per category			Has Gas Inspection Report Number of landfills per category			Has Gas Enforcement Action Number of landfills per category			Has Surface Water Action Number of landfills per category		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
Fully Subtitle D	2	0	2	0	0	1	1	0	1	0	0	0	1	0	0
Fully Lined, Partially Non- Subtitle D	7	0	5	4	0	1	5	0	2	3	0	0	2	0	0
Partially Unlined	38	6	26	22	1	9	26	3	18	10	0	5	8	0	10
Fully Unlined	24	8	106	11	2	20	17	3	36	3	0	10	9	1	18

Observations From Quantitative Data Review (Table 5-E)

Fully unlined landfills are more common in rural social settings and partially unlined landfills are more common in urban social settings. This finding is likely a function of the size of the waste streams going to the different sites. Many rural, unlined sites have not reached the capacity of their “pre-regulation” footprint and, therefore, are therefore not required to build lined WMUs at the landfill. Urban landfills, on the other hand, tend to have larger waste streams that need to be accommodated, necessitating the construction of new WMUs at the landfill. The new WMUs were then lined in accordance with the regulations in effect at the time of construction.

The relative distribution of the environmental response variables does not appear to be related to *Social Setting* when divided by *Liner Type*. However, as shown in Section 4.9, partially unlined sites are more likely to have a “yes “ value for the categories “In Corrective Action,” “Has Gas Inspection Report,” and “Has Gas Enforcement Action.”

5.2.2.5 Results and Observations: Landfill Gas Collection System

Table 5-F: Summary of Environmental Performance and Landfill Site Characteristic Data for Urban, Suburban, and Rural Landfills by *Landfill Gas Collection System*

Landfill Site Characteristic				Environmental Performance Variables											
<i>Landfill Gas Collection System Categories</i>	Number of Landfills in Study			In Corrective Action Number of landfills per category			Has Gas Inspection Report Number of landfills per category			Has Gas Enforcement Action Number of landfills per category			Has Surface Water Action Number of landfills per category		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
Has System	57	9	37	33	2	17	40	3	27	14	0	8	16	1	8
Does Not Have System	14	5	102	4	1	14	9	2	30	2	0	7	4	0	20

Observations From Quantitative Data Review (Table 5-F)

Landfill gas collection systems are relatively more common at urban and suburban landfills than at rural landfills. With the exception of “Has Gas Inspection Report” at suburban landfills and “Has Surface Water Action” at urban landfills, landfills with gas collection systems have the highest relative occurrence of each environmental performance variable in each social setting.

However, for the reasons stated in section 4.11, the existence of a landfill gas collection system may not be a good indicator of environmental performance.

5.2.2.6 Summary of Observations From Quantitative Data Review For the Five Landfill Site Characteristics

A look at the observations for the five landfill site characteristics leads to the following key observations about urban, suburban, and rural landfills:

- Urban sites are generally larger than rural sites.
- Urban landfills are relatively concentrated in areas with between 9 and 24.9 inches of annual precipitation.
- Rural landfills are distributed broadly over dry, moderate, and wet climates.
- Partially unlined landfills and landfill gas collection systems are more common in urban social settings than in rural social settings.

5.3 Summary of Environmental Performance of Active, Inactive, Closed, and Combination Landfills by Five Landfill Site Characteristics

To better understand the environmental performance of active, inactive, closed, and “combination”[‡] landfills for the time of the study, a quantitative data review was completed on five landfill site characteristics. The review of active, inactive, closed, and combination landfills looked at all possible values for each of the site characteristics (instead of two mutually exclusive values, as with the review of urban, suburban, and rural landfills in section 5.2.1). The review provided not only environmental performance information, but also a snapshot of the design and operational characteristics of the landfills in regard to the five site characteristics.

The results are summarized and compared against one another for the following five landfill site characteristics:

1. Landfill Size (Permitted Disposal Area)
2. Minimum Depth to Underlying Groundwater
3. Average Annual Precipitation
4. Liner Type
5. Final Cover Type

Each site characteristic was evaluated against the following environmental performance variables:

1. In Corrective Action
2. Has Gas Inspection Report
3. Has Gas Enforcement Action
4. Has Surface Water Action

The data was taken from the Task 2 database and covers the time period January 1998 through December 2001.

[‡] For purposes of this study, a “combination” landfill is one that consists of more than one waste management unit, with the individual units being in different operational states (for example, in a landfill with two units, one unit may be active and the other may be closed).

5.3.1 Results and Observations: Landfill Size (Permitted Disposal Area)

Table 5-G: Summary of Environmental Performance and Landfill Site Characteristic Data for Active, Inactive, Closed, and Combination Landfills by *Landfill Size (Permitted Disposal Area)*

Landfill Site Characteristic					Environmental Performance Variables															
Landfill Size (Permitted Disposal Area) Categories (acres)	Number of Landfills in Study				In Corrective Action Number of landfills per category				Has Gas Inspection Report Number of landfills per category				Has Gas Enforcement Action Number of landfills per category				Has Surface Water Action Number of landfills per category			
	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination
0–9.9	12	7	9	0	2	2	0	0	5	1	0	0	2	0	0	0	0	2	1	0
10–99.9	66	23	16	17	11	7	6	10	31	9	7	13	9	1	0	6	13	6	0	6
100 or more	50	4	6	14	19	2	2	10	30	3	4	9	11	1	0	1	16	0	0	5

Observations From Quantitative Data Review (Table 5-G)

Landfills that have less than 10 acres in permitted disposal area are either active, inactive, or closed, but not a combination of these site statuses.

Closed landfills, regardless of permitted disposal area, have a low relative occurrence of “Has Surface Water Action” and “Has Gas Enforcement Action,” whereas combination sites have a high relative occurrence of “Has Surface Water Action” and “Has Gas Enforcement Action.” These observations are similar to those found in Section 4.12.1.

5.3.2 Results and Observations: Minimum Depth to Underlying Groundwater

Table 5-H: Summary of Environmental Performance and Landfill Site Characteristic Data for Active, Inactive, Closed, and Combination Landfills by *Minimum Depth to Underlying Groundwater*

Landfill Site Characteristic					Environmental Performance Variables															
Minimum Depth to Underlying Groundwater Categories (feet)	Number of Landfills in Study				In Corrective Action Number of landfills per category				Has Gas Inspection Report Number of landfills per category				Has Gas Enforcement Action Number of landfills per category				Has Surface Water Action Number of landfills per category			
	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination
0–4.9	19	5	5	8	3	4	1	5	8	3	2	6	2	0	0	0	6	2	0	4
5–99.9	67	19	20	19	22	4	6	12	39	7	9	13	13	2	0	6	17	6	0	5
100 or more	42	10	6	4	7	3	0	3	19	3	1	3	7	0	0	1	6	0	1	2

Observations From Quantitative Data Review (Table 5-H)

Combination landfills are more common in areas of relatively shallow groundwater than in areas of deep groundwater.

For active and inactive landfills, sites with more shallow groundwater tend to have a higher relative occurrence of “Has Surface Water Action.” This trend supports the findings in Section 4.7.

5.3.3 Results and Observations: Average Annual Precipitation

Table 5-I: Summary of Environmental Performance and Landfill Site Characteristic Data for Active, Inactive, Closed, and Combination Landfills by *Average Annual Precipitation*

Landfill Site Characteristic					Environmental Performance Variables															
Average Annual Precipitation Categories (inches)	Number of Landfills in Study				In Corrective Action Number of landfills per category				Has Gas Inspection Report Number of landfills per category				Has Gas Enforcement Action Number of landfills per category				Has Surface Water Action Number of landfills per category			
	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination
0–8.9	44	13	7	5	4	4	3	1	16	5	2	2	0	0	0	1	3	1	0	0
9–24.9	69	12	16	24	22	3	5	19	44	6	8	19	22	2	0	6	18	2	1	10
25 or more	15	9	8	2	6	4	0	0	6	2	1	1	0	0	0	0	8	5	0	1

Observations From Quantitative Data Review (Table 5-I)

Combination landfills are more common in areas with between 9 and 24.9 inches of average annual precipitation.

With the exception of closed sites, landfills with greater average annual precipitation have a higher relative occurrence of “Has Surface Water Action.” With the exception of closed and combination sites, landfills with greater average annual precipitation have a higher relative occurrence of “In Corrective Action.”

5.3.4 Results and Observations: Liner Type

Table 5-J: Summary of Environmental Performance and Landfill Site Characteristic Data for Active, Inactive, Closed, and Combination Landfills by *Liner Type*

Landfill Site Characteristic					Environmental Performance Variables															
<i>Liner Type</i> Categories	Number of Landfills in Study				In Corrective Action Number of landfills per category				Has Gas Inspection Report Number of landfills per category				Has Gas Enforcement Action Number of landfills per category				Has Surface Water Action Number of landfills per category			
	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination
Fully Subtitle D	4	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0
Fully Lined, Partially non- Subtitle D	9	0	2	1	3	0	1	1	4	0	2	1	2	0	0	1	2	0	0	0
Partially Unlined	42	3	4	21	14	1	3	14	28	2	3	14	10	1	0	4	11	1	0	6
Fully Unlined	73	31	25	9	14	10	3	5	32	11	6	7	10	1	0	2	15	7	1	5

Observations From Quantitative Data Review (Table 5-J)

Combination sites are more likely than sites with any other liner type to be partially unlined. Inactive sites are more likely than sites with any other liner type to be fully unlined.

5.3.5 Results and Observations: Final Cover Type

Table 5-K. Summary of Environmental Performance and Landfill Site Characteristic Data for Active, Inactive, Closed, and Combination Landfills by *Final Cover Type*

Landfill Site Characteristic					Environmental Performance Variables															
Final Cover Type Categories	Number of Landfills in Study				In Corrective Action Number of landfills per category				Has Gas Inspection Report Number of landfills per category				Has Gas Enforcement Action Number of landfills per category				Has Surface Water Action Number of landfills per category			
	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination	Active	Inactive	Closed	Combination
Fully Covered	0	10	31	7	0	3	8	6	0	2	11	7	0	0	0	1	0	2	1	3
Partially Covered	14	0	0	16	5	0	0	8	8	0	0	8	7	0	0	4	6	0	0	4
Fully Uncovered	114	24	0	8	27	8	0	6	58	11	0	7	15	2	0	2	23	6	0	4

Observations From Quantitative Data Review (Table 5-K)

All closed landfills are fully covered. All active landfills are at least partially uncovered. This data supports the implicit relationship between the *Final Cover Type* and *Site Status* variables.

With the exception of “Has Gas Enforcement Action,” fully covered closed sites have a lower relative occurrence of each environmental performance variable than fully covered inactive sites.

5.3.6 Summary of Observations From Quantitative Data Review For the Five Landfill Site Characteristics

A look at all of the observations for the five landfill site characteristics leads to the following key observations about active, inactive, closed, and combination landfills:

- Landfills that are less than 10 acres in permitted disposal area are either active, inactive, or closed, but not a combination of these site statuses.
- Landfills of this size generally consist of one WMU, rather than consisting of multiple WMUs.
- Combination landfills are more common in areas of relatively shallow groundwater and moderate average annual precipitation.
- Combination sites are more likely to be partially unlined than any other *Liner Type*.

- As stated in Section 4, combination sites are generally larger and consist of multiple WMUs built at different times. This has resulted in a wider range of liner types and site statuses.
- With the exception of closed sites, landfills with greater average annual precipitation have a higher relative occurrence of “Has Surface Water Action.” With the exception of closed and combination sites, landfills with greater average annual precipitation have a higher relative occurrence of “In Corrective Action.” These observations lead to the conclusion that with more rain, there is more potential for erosion and more potential for leachate generation.
- All closed landfills are fully covered. All active landfills are at least partially uncovered. This data supports the implicit relationship between the *Final Cover Type* and *Site Status* variables.

6 Conclusions

This section presents the key findings from the analyses summarized in Sections 2 through 5. As a whole, MSW landfills in California are diverse in size, setting, and design but similar in function. Even though the sites vary widely in their characteristics, this study has identified common characteristics that, as a trend, can be associated with environmental compliance concerns as defined in Section 3.

6.1 *Key Findings of Landfill Site Characteristics*

6.1.1 Landfill Variety

As described in Section 2, the 224 landfills contained within this study vary greatly. The landfills vary in permitted disposal area from 1 acre to 800 acres. The permitted volume ranges from 2,100 cubic yards to approximately 185 million cubic yards. The landfills are permitted to accept from 1 ton of MSW per day to over 13,000 tons per day.

Some landfills date back to the 1910s and 1920s, and others are less than 15 years old. Several newer landfills are completely lined with Subtitle D-compliant liners, while many older sites are completely unlined, as allowed by the regulations; still other sites have a variety of lined and unlined WMUs built at different times.

6.1.2 Typical California Landfill

Based on the results of the statistical evaluation of the database, the typical MSW landfill in California at the time of the study can be described as shown in Table 5-A (Section 5.1). The typical landfill is publicly owned, active, located inland, either fully unlined or partially unlined (in the case of active sites), fully uncovered, and has no gas collection system. The typical landfill has a permitted disposal area of 55.5 acres and a permitted disposal volume of 2.7 million cubic yards. The typical landfill is underlain by sand and/or gravel, has a minimum depth to underlying groundwater of 34.5 feet, and receives an average annual precipitation of 16 inches.

6.1.3 Remaining Capacity

The permitted remaining capacity for the landfills during the timeframe of the study ranged from approximately 2,000 cubic yards to approximately 95 million cubic yards. For the entire state, the total remaining capacity was approximately 1.5 billion cubic yards, which equates to approximately 44 cubic yards per person. This is roughly equivalent to a cube that is 11 feet by 11 feet by 11 feet.

In general, California's remaining capacity for the time frame of the study was concentrated around the population centers (may include surrounding counties) of Los Angeles, San Francisco, Sacramento, and San Diego.

Based on the information gathered for the period from January 1, 1998, to December 31, 2001, the following nine counties had no remaining MSW capacity: Alpine, Mendocino, Modoc, Nevada, San Francisco, Sutter, Tehama, and Trinity. Between 2001 and the date of this report, additional landfills have closed or become inactive. This created an additional three counties with zero remaining capacity; Del Norte, Humboldt, and Tuolumne.

This closure pattern suggests that, increasingly, portions of primarily rural California cannot meet the landfill needs of their residents without hauling out of county or to neighboring states. Often, smaller, rural, county-owned landfills have closed and waste streams have been diverted to larger, centralized landfills.

6.2 Key Findings of Environmental Performance Analyses By Landfill Site Characteristics

Through the screening analyses conducted in this part of the study, site characteristics were analyzed with respect to the environmental performance variables. As a result, common characteristics were identified that were correlated to environmental performance or compliance problems. While a particular site characteristic may be more common among sites with certain characteristics, it does not necessarily mean that the site characteristics were the underlying cause for the actions taken by the regulators, but only that a correlation exists.

As described in Section 7, Phase II of the study will involve detailed analyses of individual sites to better understand the underlying reasons that a landfill is not in compliance and if it is related to current regulation.

6.2.1 Sites Most Likely to be in Corrective Action

The results of the statistical analysis presented in Section 4 demonstrate that sites most likely to be in corrective action or to have water-related cleanup and abatement orders are larger, located in urban areas, at least partially unlined, and located in areas of higher-than-average precipitation. These sites also tend to be privately owned and have landfill gas collection systems.

In contrast, small, rural, unlined sites in dry climates tend to have a lower occurrence of corrective action or water-related cleanup and abatement orders. These sites also tend to be publicly owned and are not required to have landfill gas collection systems.

These findings suggest that if all else is equal, a larger volume of waste spread over a larger area with higher precipitation results in a higher potential for a release into groundwater.

These larger, urban sites may tend to be more intensely monitored and attract greater regulatory scrutiny, thus leading to a higher relative occurrence of corrective action measures and cleanup and abatement orders. However, the data collected in this study can neither support nor refute this hypothesis.

6.2.2 Sites Most Likely Have Surface Water Action

The statistical analyses demonstrate that landfills in drier climates tend to have fewer surface water compliance issues, including leachate seeps and excessive erosion. It is logical to conclude that greater precipitation leads to greater potential for both erosion and leachate generation.

The analyses also show that sites that have undergone closure have a significantly lower occurrence of surface water actions. This suggests that construction of an approved final cover system can reduce the potential for surface water impacts.

6.2.3 Sites Most Likely to Have Air Quality and Gas Actions

Larger urban landfills that are greater than 60 years old, with higher annual precipitation, a combination of liner types, and that are partially closed are more likely to have landfill gas violations or notices to comply than other sites.

These findings suggest that if all else is equal, a larger volume of waste in areas of higher precipitation results in more landfill gas with a higher potential for gas compliance issues.

These larger, urban sites may tend to be more intensely monitored and attract greater regulatory scrutiny, thus leading to a higher relative occurrence of gas-related violations. However, the data collected in this study can neither support nor refute this hypothesis.

6.3 Key Findings Based on Non-Quantified Observations

In addition to the quantified results presented above, a number of non-statistical observations were made in the course of the study and are described in this section.

6.3.1 Inconsistency Among Regulatory Agencies

One primary difficulty stems from the fact that the three primary regulatory agencies (EAs, RWQCBs, and AQMDs/APCDs) regulate and oversee the landfills differently. These differences are necessitated by the goals of each agency.

The EA regulates the landfills based on MSW operational units—generally on a site-wide basis. The RWQCBs regulate the landfills based on individual WMUs. EAs do not recognize the individual WMUs that may comprise the landfill. All of the information is kept for the “whole” site and is not broken down into individual WMUs. For example, information on capacity, compliance, cover type and site status is reported for the whole landfill and not broken down to specific WMUs. As a result, it is difficult to determine where a problem with performance or compliance has occurred at a landfill. Also, there are cases where two adjacent operational units are regulated separately as individual landfills, when they should be regulated as one landfill.

RWQCBs issue site-wide permits that can include both MSW and non-MSW WMUs (for example Class II surface impoundments). For purposes of this study, environmental performance and compliance records for each site were determined for MSW WMUs and did not include the non-MSW WMUs.

The AQMDs/APCDs regulate the landfills primarily based on the equipment in operation. In some cases, there are adjoining landfills with shared gas collection systems. For purposes of this study, performance and compliance issues then become difficult to assign to one landfill vs. the other. As a result, it was difficult to determine which landfill actually had a problem with performance or compliance.

Additionally, within each type of agency, there are differences in the information available. Even seemingly simple pieces of data can become complex. As an example, the EAs issue a SWFP for each landfill that lists, among other things, the design capacity of the site. However, this entry may have a range of meanings depending on the landfill. In some cases, it refers to the total volume of the landfill as measured from the base grades to the final grades. In others it refers to the actual MSW volume (total airspace minus daily cover and final cover volumes). Still others refer to the remaining capacity, rather than total capacity.

These observed inconsistencies most likely have little, if any, effect on the enforcement of the regulations for any given site. All parties involved presumably understand the site-specific requirements. The difficulty comes only when comparing a group of sites where these differences affect the consistency of the data. In a study such as this one, a cross-media evaluation becomes increasingly difficult with these types of added complexity.

7 Recommendation of 40 MSW Landfills for Phase II of Study

7.1 *Introduction*

This section contains a list of 40 MSW landfills taken from the original 224 MSW landfills and recommended by GeoSyntec for Phase II of the study, the assessment of regulatory effectiveness. GeoSyntec selected 37 sites based on their general site characteristics and environmental performance. Additionally, the CIWMB identified three sites that might be impacted by regulations pertaining to very low waste acceptance levels that delay or avoid closure (“trickling waste”) (27 CCR section 21110(b)). GeoSyntec included these sites in the list of 40 landfills.

In addition to the 40 MSW landfills identified for assessment of regulatory effectiveness, the Phase II portion of the study will also include 13 MSW landfills that closed prior to 1993. The addition of these 13 landfills allows the assessment of regulatory effectiveness to be more complete by providing a longer closure period for review. The 13 landfills were selected by CIWMB staff working with staff from the SWRCB and ARB, and consist of the following sites:

1. Mission Canyon (Unit 1) (Canyons 1-3)—Los Angeles County
2. Mission Canyon (Unit 2) (Canyons 4-7)—Los Angeles County
3. Mission Canyon (Unit 3) (Canyon 8)—Los Angeles County
4. Coastal/Santa Clara Landfill—Ventura County
5. East Third Avenue Landfill—San Mateo County
6. Adelanto Disposal Site—San Bernardino County
7. Madrone Landfill—Santa Clara County
8. Old Mount Shasta Dump—Siskiyou County
9. South Chollas Sanitary Landfill—San Diego County
10. Ballard Canyon Road—Santa Barbara County
11. Coyote Canyon Sanitary Landfill—Orange County
12. Buckeye Disposal Site—Shasta County
13. McCourtney Road Landfill —Nevada County

7.2 *Forty Landfills Recommended for Further Study*

The 40 landfill from the Task 2 database selected for Phase II are shown in Table 7A. Also included in this table are the site characteristics employed in making the selection.

Table 7-A: Phase II Study Site List

	Landfill Name and County	Vertical Expansion Over Unlined Unit	Fully Subtitle D or Alternative Liner	"Typical" California MSW Landfill	Gas Extraction System	Gas-To-Energy System	Bioreactor, Leachate/Condensate Recirculation	Mechanical Pre-Treatment	Closed with GM cap	Closed With GCL Cap	Closed With Monofill or ET Cover	Title 27 Prescriptive Cover	Trickling Waste Site
1	Altamont Landfill and Resource Recovery Facility (Alameda County)				X	X							
2	Amador County Landfill/Buena Vista Class II Landfill (Amador County)			X									
3	Baker Refuse Disposal Site (San Bernardino County)										X		
4	Bakersfield Metropolitan (Bena) Sanitary Landfill (Kern County)												
5	Bass Hill Landfill (Lassen County)			X									
6	Bieber Landfill (Lassen County)									X			
7	Big Oak Flat Landfill (Tuolumne County)												X
8	Billy Wright Disposal Site (Merced County)												
9	Bradley Landfill West and West Extension (Los Angeles County)				X	X							
10	Chateau Fresno Landfill (Fresno County)				X				X				
11	Chicago Grade Landfill (San Luis Obispo County)	X			X								
12	Chiquita Canyon Sanitary Landfill (Los Angeles County)				X						X		
13	City of Palo Alto Landfill (Santa Clara County)				X	X							
14	City of Willits Disposal Site (Mendocino County)								X				
15	Corral Hollow Landfill				X							X	

	Landfill Name and County	Vertical Expansion Over Unlined Unit	Fully Subtitle D or Alternative Liner	"Typical" California MSW Landfill	Gas Extraction System	Gas-To-Energy System	Bioreactor, Leachate/Condensate Recirculation	Mechanical Pre-Treatment	Closed with GM cap	Closed With GCL Cap	Closed With Monofill or ET Cover	Title 27 Prescriptive Cover	Trickling Waste Site
	(San Joaquin County)												
16	Crazy Horse Sanitary Landfill (Monterey County)				X	X							
17	Cummings Road Landfill (Humboldt County)				X								X
18	Double Butte Sanitary Landfill (Riverside County)				X								
19	Eastern Regional Landfill (Placer County)				X							X	
20	Edwards AFB Main Base Sanitary Landfill (Kern County)							X					
21	Frank R. Bowerman (Orange County)				X								
22	Furnace Creek Landfill (Inyo County)										X		
23	Hanford Sanitary Landfill (Kings County)				X					X			
24	Highgrove Sanitary Landfill (Riverside County)				X						X		
25	Holtville Disposal Site (Imperial County)												X
26	John Smith Road Class III Landfill (San Benito County)			X	X								
27	Keller Canyon Landfill (Contra Costa County)		X		X		X						
28	Lopez Canyon Sanitary Landfill (Los Angeles County)				X	X					X	X	
29	Morongo Disposal Site (San Bernardino County)									X			
30	Norcal Waste Systems Ostrom Road Landfill (Sutter County)		X										

	Landfill Name and County	Vertical Expansion Over Unlined Unit	Fully Subtitle D or Alternative Liner	"Typical" California MSW Landfill	Gas Extraction System	Gas-To-Energy System	Bioreactor, Leachate/Condensate Recirculation	Mechanical Pre-Treatment	Closed with GM cap	Closed With GCL Cap	Closed With Monofill or ET Cover	Title 27 Prescriptive Cover	Trickling Waste Site
31	Olinda Alpha Sanitary Landfill (Orange County)				X	X							
32	Puente Hills Landfill (Los Angeles County)				X	X							
33	Ramona Landfill (San Diego County)			X	X								
34	San Marcos Landfill (San Diego County)	X			X	X			X				
35	Simi Valley Landfill & Recycling Center (Ventura County)	X			X								
36	South Coast Solid Waste Site (Mendocino County)												
37	Sunshine Canyon Sanitary Landfill County Extension (Los Angeles County)		X		X								
38	Sycamore Sanitary Landfill (San Diego County)				X	X							
39	West Central Landfill (Shasta County)												
40	Yolo County Central Landfill (Yolo County)				X	X	X						

The geographic distribution of the sites is shown in Figure 7.1. The number adjacent to each site marker corresponds to the site number listed in Table 7-A. Four landfills—West Central Landfill, Billy Wright Disposal Site, South Coast Solid Waste Site, and Bakersfield Metropolitan (Bena) Sanitary Landfill—were included to provide a more representative geographic distribution. Figure 7.1 shows that the sample of 40 sites appears relatively well distributed throughout the state.

Figure 7.1 Phase II Study Map



These 40 sites, along with the 13 sites closed prior to 1993, are the basis for Phase II of the Landfill Facility Compliance Study.

Appendix A: A Brief Overview of Non-MSW Landfills

A.1 Introduction

The purpose of this section is to advise the reader of another set of solid waste landfills that are not addressed by the contracted study. These are solid waste landfills that do not accept MSW. Each of the sites within the 224-landfill inventory accepted MSW. The non-MSW landfills were not included in the Task 2 database inventory and were not included in the screening analyses presented in Sections 4 and 5. However, the following section provides a brief overview of some of the non-MSW sites.

A.2 Non-MSW Waste Disposal Sites

As part of the scope of work to provide a brief overview of non-MSW landfills, GeoSyntec collected a limited amount of data on some non-MSW California disposal sites. At the beginning of this project, the CIWMB, working with staff from the SWRCB and ARB, identified eight non-MSW sites to be included in the overview. These landfills range in size from 2 to 160 acres. The sites are listed in Table A-A.

Table A-A Partial List of Non-MSW Waste Disposal Sites

Disposal Site	County
Ascon Landfill (Wilmington)	Los Angeles
Desert Valley Monofill	Imperial
Geothermal, Inc. Facility	Lake
I-580 Freeway Class II Landfill	Contra Costa
McKittrick Waste Treatment Site	Kern
Twin Bridges Class II Landfill	Shasta
USAF March AFB Landfill	Riverside
USAF Norton AFB Landfill	San Bernardino

As indicated in Table A-A, these eight landfills are located throughout California. As such, the landfills fall in a wide range of settings. Social settings vary from rural to urban. Annual precipitation ranges from 3 inches to 44 inches, and physical settings range from inland to desert.

A.3 Waste Types

The waste types permitted for disposal in these eight disposal sites vary from site to site. Permits for each site (Waste Discharge Requirements and Solid Waste Facilities Permit) indicate allowable waste types and prohibited waste types. Collectively, permits for these landfills authorize for disposal the following waste types:

- Ash.
- Demolition debris.
- Primary clarifier solids.
- Carbonates.

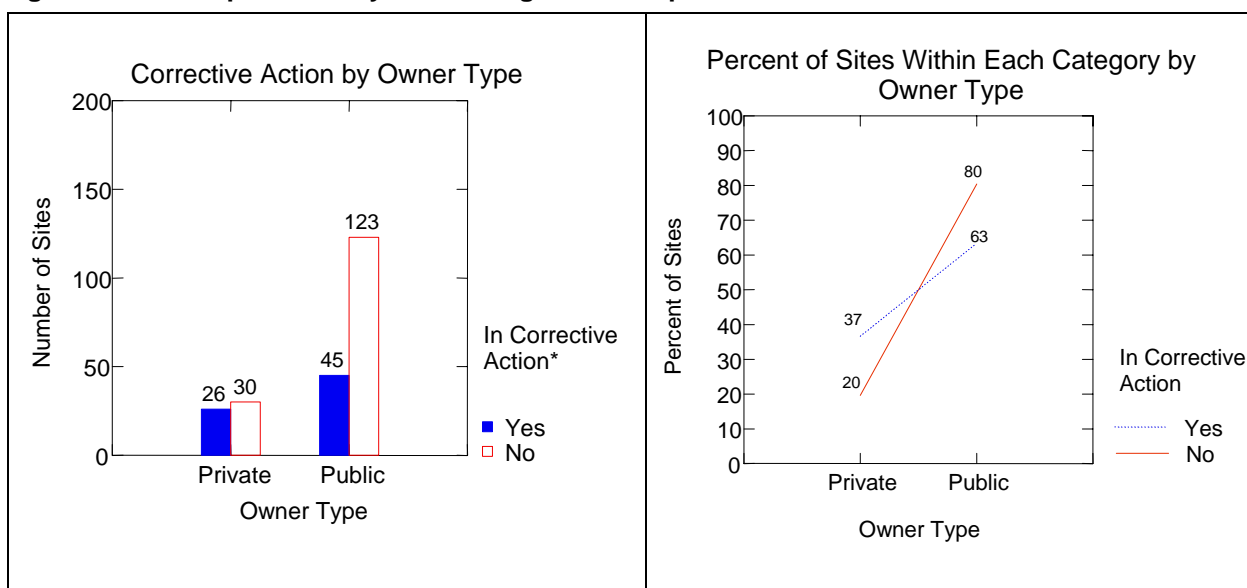
- Filter cake.
- Drilling mud.
- Drilling cuttings.
- Soil-contaminated geothermal brines.
- Nonhazardous petroleum-contaminated soil.
- Fiber and wood residue.
- Industrial wastes.
- Concrete and asphalt rubble.
- Dihydrogen sulfide abatement sludge.

Appendix B-1: Statistical Analysis Processes Used in Study and General Explanations

B-1.1 Evaluation of Categorical Independent Variables

In order to identify possible correlation between select independent and dependent variables, it is useful to first conduct a simple graphical analysis of the data as part of the exploratory data analysis (EDA). The graphical results of the EDA are provided in Appendices B-2 through B-5 as part of the summary of results. As an example of the approach taken, this section considers the relationship between landfill ownership type (private or public) and the variable “In Corrective Action.” (based on RWQCB monitoring status). Figure B-1-1 displays both the frequency (bar chart on the left) and relative percentage of each independent variable category (line chart on the right) as seen in Appendices B-2 through B-5.

Figure B-1-1. Graphical Analysis of Categorical Independent Variable



* In Appendices B-2 through B-5, the legend lists “In Corrective Action” or “Not in Corrective Action” instead of “In Corrective Action”/“Yes” or “No.”

The bar chart on the left displays the number of sites that are and are not in the category "In Corrective Action" grouped by either private or public owner types. The chart provides some indication that there appears to be a difference in the proportion of privately owned sites in corrective action when compared with publicly-owned sites. However, any potentially significant relationship between owner type and "In Corrective Action" cannot be determined based strictly on the counts displayed here, since there are many more public sites in the database.

The values displayed in the line chart on the right represent the distribution of the dependent variables with relation to the independent variables. As shown by the dashed line in this chart, privately owned sites make up approximately 37 percent of those in the "In Corrective Action" category, while publicly owned sites make up the remaining 63 percent. As shown by the solid line in this chart, privately owned sites make up approximately 20 percent of those not in the "In Corrective Action" category, while publicly owned sites make up the remaining 80 percent.

Because there are many fewer privately owned sites than publicly owned sites, it is logical to expect that the private sites will make up a smaller percentage of each dependent variable category. However, as demonstrated by the difference in the slope of the two lines in this diagram, private sites make a greater relative contribution to the "In Corrective Action" response. The converse is true for public sites.

The EDA graphical results provide a preliminary assessment of the data, which assists with subsequent hypothesis testing and screening of results. However, without a more rigorous statistical analysis, it is unclear if the differences shown in these two charts are statistically significant.

B-1.2 Logistic Regression Analysis of Categorical Independent Variables

Logistic regression analysis seeks to use one or more independent variables to estimate the odds of one outcome occurring versus another, where the outcomes are discrete, categorical, dependent variables. The basic form of a logistic regression model is as follows:

$$LN\left(\frac{P_1}{P_2}\right) = \alpha + \beta X$$

where:

P_1 = probability of dependent variable category 1

P_2 = probability of reference dependent variable category 2

α = intercept constant

β = slope coefficient

X = independent (explanatory) variable

The form above is for a discrete dependent variable consisting of only two categories ("is dichotomous" or "binomial"), where the sum of the values P_1 and P_2 is equal to 1. It is clear from this to see that $P_2 = 1 - P_1$. Logistic regression analysis may also be conducted for dependent variables divided into more than two discrete categories (the sum of all individual probabilities equal to 1), although interpretation of the results is often less intuitive. For the purposes of this report, only binomial logistic analysis was conducted. For example, each of the dependent variables was defined in terms of two possible outcomes.

There are a number of measures of the results of a logistic regression analysis. Here the results are interpreted using the odds ratio $\frac{P_1}{P_2}$, the bounds on the odds ratio, and the p-value. From the

odds ratio, it is possible to quantify how much more or less likely outcome #1 (in this case, "In Corrective Action") is than outcome #2 (in this case, "Not in Corrective Action") for each independent variable category (in this case, "Private" or "Public"). For a binomial logistic regression, outcome #2 is considered the default, or reference value, of the dependent variable. The reference value is selected for each variable based on what would be considered the default value.

Like the dependent variable, the independent variable in the logistic regressions conducted as part of this study is discrete, and each of the variable categories is expressed in comparison to a reference category. In the example discussed here, the independent variable is divided into only

two categories, with “Public” serving as the reference (the default or base value for the independent variable). The independent variable therefore takes a single value: $\frac{\text{Private}}{\text{Public}}$.

The reference category answers the question “More likely than what?” In this case, private sites may be more or less likely to be in the “In Corrective Action” category than public sites. Without identifying the independent variable categories in terms of a reference category, the resulting odds ratios would be meaningless.

All statistical analyses conducted in this study were generated using the SYSTAT 10 software. The Logit routine was used for logistic regression. A summary of the logistic regression output for *Owner Type* versus “In Corrective Action” is provided in Table B-1-A.

Table B-1-A: Example Binary Logit

$LN \left[\frac{\text{Pr(In Corrective Action)}}{\text{Pr(Not in Corrective Action)}} \right] = -1.0055 + 0.86242 \left(\frac{\text{Private}}{\text{Public}} \right)$				
Coefficient	Value	SE	t-ratio	p-value
Constant	-1.0055	0.17422	-5.77	0.0000
Private/Public	0.86242	0.31960	2.70	0.00697
Parameter	Odds Ratio		Upper 95% bound	Lower 95% bound
Private/Public	2.369		4.432	1.266

The “Constant” coefficient in the resulting model does not affect how the dependent and independent variables change in relation to one another, so the results for the constant are not relevant to analysis. The reported p-value for the Private/Public slope coefficient (β) indicates that the probability of this result occurring by chance is approximately 0.7 percent, so the result is considered significant (using a threshold of 5 percent or 0.05). This means that the result is significant at the 5 percent significance level (99.5 percent confidence).

The odds ratio is calculated by taking the exponent of the slope coefficient. In this example, the odds ratio is greater than one, indicating that it is *more likely* that the independent variable “Private/Public” is associated with outcome #1 (“In Corrective Action”). Because the independent variable is itself a ratio, the final result may be interpreted as follows:

Based on the available data, private sites are **2.4 times more likely** to be in the category “In Corrective Action” than public sites.

Table B-1-B below provides an example of how the results shown above in Table B-1-1 are summarized in Appendices B-2 through B-5.

Table B-1-B: Sample Categorical Independent Variable Results

Summary Table of Results—Logistic Regression (Reference Dependent Variable is “Not in Corrective Action”)					
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95 Percent Bound on Odds Ratio	Lower 95 Percent Bound on Odds Ratio
Private	Public	0.007	2.369	4.432	1.266

The odds ratio is an estimated value computed by the model. The quality of the estimate is based on a number of factors, including sample size. A small sample size ($n < 20$) is unlikely to yield significant results unless the relationship between independent factor and dependent response is very strong. One method of evaluating the significance of the odds ratio is examination of the upper and lower bounds. The SYSTAT software uses a 95 percent confidence interval to evaluate the odds ratio (for example, the probability that the odds ratio falls within the range of the upper and lower bound is 95 percent). This confidence interval is consistent with the use of the 95 percent confidence interval for all analyses conducted in this study and is an appropriate level of significance for environmental data analysis.

If the lower bound is less than 1 but the upper bound is greater than 1, then the result is not considered significant. In these cases, the probability will also be greater than 0.05, another indication that the result is not significant.

If both the upper and lower bounds are less than 1 (the p-value will also be less than 0.05), then the odds ratio will also be less than 1. Interpretation of the results, therefore, is based on the inverse of the odds ratio and the corresponding upper and lower bounds. In the example displayed in Table B-1-B, various categories of *Physical Setting* are regressed against “In Corrective Action.” The initial odds ratio was not considered significant for any of the independent variable categories; however, the inverse odds ratio revealed a significant relationship between desert sites and “In Corrective Action,” compared to inland sites. To interpret the results, “In Corrective Action” is considered the reference dependent variable (instead of “Not in Corrective Action”), and the calculated odds ratio is expressed as follows:

Desert sites are approximately **3.7 times less likely** to be in corrective action than inland sites.

Table B-1-C: Interpretation of Inverse Odds Ratio

Summary Table of Results—Logistic Regression (Reference Dependent Variable is “In Corrective Action”)					
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95 Percent Bound on Odds Ratio	Lower 95 Percent Bound on Odds Ratio
High Desert	Inland	0.117	5.408	44.649	0.655
Desert	Inland	0.001	3.681	8.188	1.655
Alpine	Inland	0.235	2.254	8.616	0.589

Coastal	Inland	0.599	0.761	2.11	0.274
Estuarine	Inland	0.399	2.028	10.473	0.393

It is important to note that the logistic regression approach does not yield results that may be used to model possible outcomes, as might be done with linear regression. The odds ratio calculated for each independent variable is expressed in terms of the independent reference category (in this case, “Public”); therefore, the “odds” of a particular outcome (for example, “In Corrective Action”) occurring is specific to the comparison being made. This becomes increasingly important for independent variables with more than two categories, since each reported odds ratio applies to only a subset of the entire sample.

Given this caveat, the simplest and most broadly applicable interpretation of results for the categorical independent variables is whether or not they indicate that a particular independent variable category yields a statistically significant result. A baseline or reference category is selected for each variable. Generally, the most common category is selected (for example, in Table B-1-C, the Inland category is the reference category because it is the most common *Physical Setting* category.) All of the remaining independent variable categories (such as *Desert*, *High Desert*, *Alpine*) are then compared against the reference category. Therefore, compared to those categories that do not exhibit a significant result, the significant category or categories may be assumed to exhibit a stronger correlation with the dependent variable. The magnitude of the odds ratio does indicate the strength of the relationship; however, the actual magnitude is typically less important than the significance of the relationship, and it is also less significant than whether the dependent variable is directly or inversely proportional to the independent variable.

B-1.3 Evaluation of Continuous Independent Variables

The logistic regression model is not applicable to independent variables that are continuous, unless they may be made discrete. To analyze continuous variables, an analysis of variance was used to determine whether the higher or lower range of the independent variable (for example, *Annual Precipitation*) is more closely associated with the different dependent variable outcomes (in this case, “In Corrective Action” or “Not in Corrective Action”).

The most common two-sample hypothesis test is the independent-sample t-test, which assumes that both samples are drawn from normally distributed populations (the test also applies to appropriately transformed data sets). When the population distribution is not known, the one-sample Lilliefors test may be used to assess whether a sample is likely drawn from a normal or lognormal population. Application of the Lilliefors test to the continuous independent variables did not indicate that the variables are well represented by either normal or lognormal distributions.

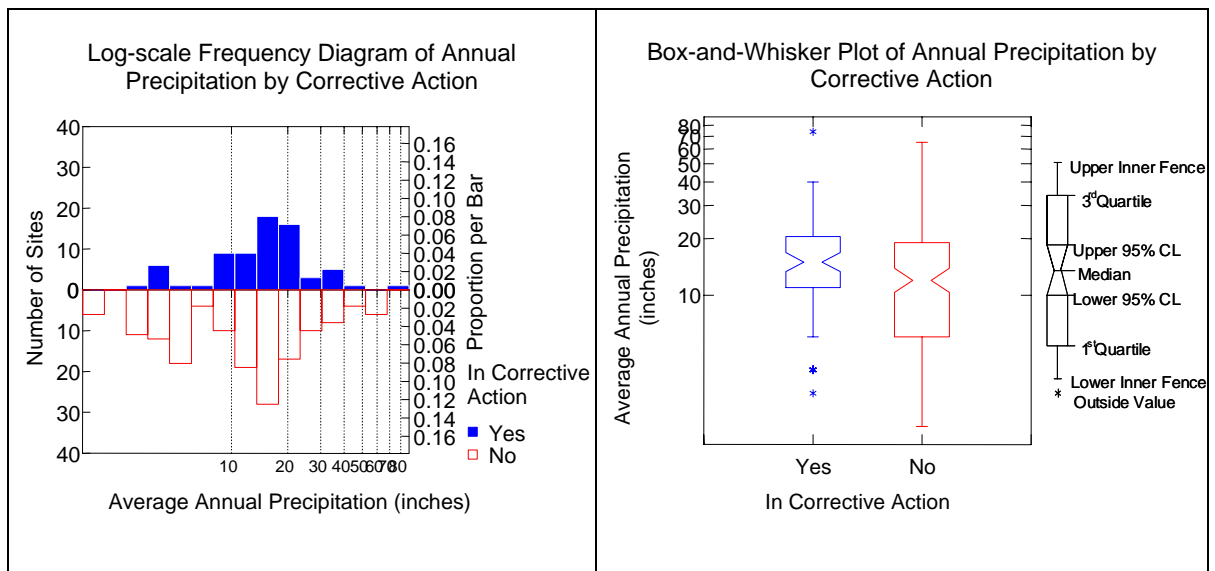
When the standard t-test is not applicable, a robust non-parametric alternative is the Kruskal-Wallis test, which like the t-test evaluates the probability that two or more samples are drawn from the same population (the two-sample form of this test is also referred to as the Mann-Whitney test). The Kruskal-Wallis test was conducted for the continuous independent variables, with the two dependent variable outcomes representing the two samples analyzed. For example, the “In Corrective Action” variable defines sites that are in the category “In Corrective Action” (“Yes” values) and sites that are not in the “In Corrective Action” category (“No” values). Table B-1-C displays an example output for *Annual Precipitation*, as it is summarized in Appendices B-2 through B-5.

Table B-1-C: Example Continuous Independent Variable Results

Summary Table of Results Kruskal-Wallis Analysis of Variance	
Independent Variable Category	Probability
Annual Precipitation	0.033

The Kruskal-Wallis test only indicates whether the difference in the two samples is statistically significant. It does not indicate which sample is greater—that is, which sample has a higher median value. This may be assessed by graphical analysis or by examining descriptive statistics (median values) for each sample. The box-and-whisker plot for the *Average Annual Precipitation* example provided on the right side of Figure B-1-2 reveals that precipitation at sites in the “In Corrective Action/Yes” category tend to be slightly greater than at sites in the “No” category. This helps to confirm what might be expected: sites that experience greater precipitation are more likely to have groundwater compliance issues. The histogram on the left side of Figure B-1-2 provides the relative size of each sample and some idea of their distribution. It appears that measured average annual precipitation at sites in the “In Corrective Action/Yes” category is more concentrated about the median value than at sites in the “No” category.

Figure B-1-2: Boxplot For Continuous Independent Variable

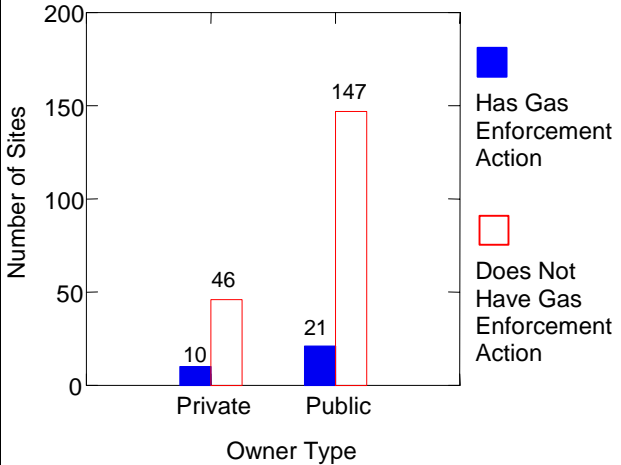
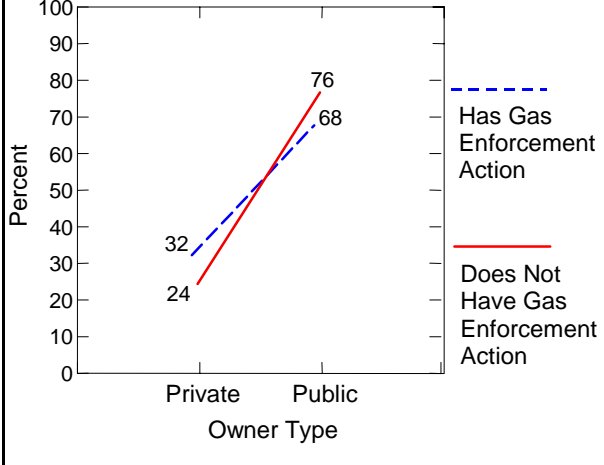


* In Appendices B-2 through B-5, the legend lists “In Corrective Action” or “Not in Corrective Action” instead of “In Corrective Action”/“Yes” or “No.”

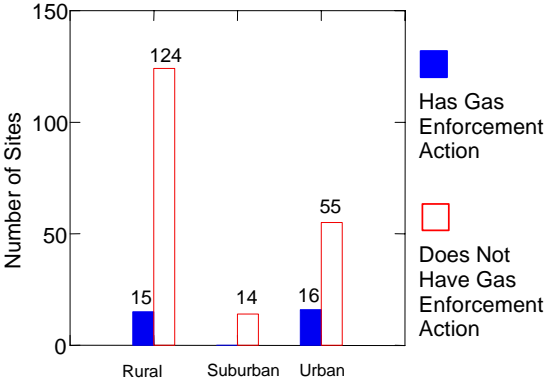
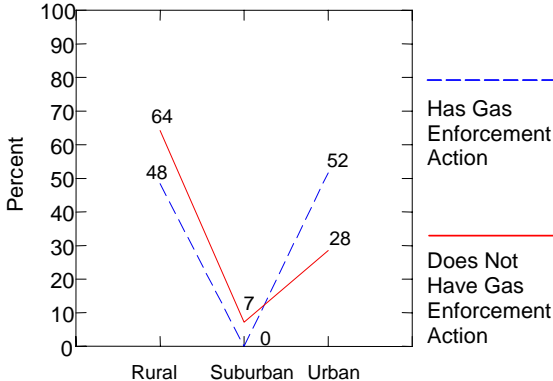
Appendix B-2

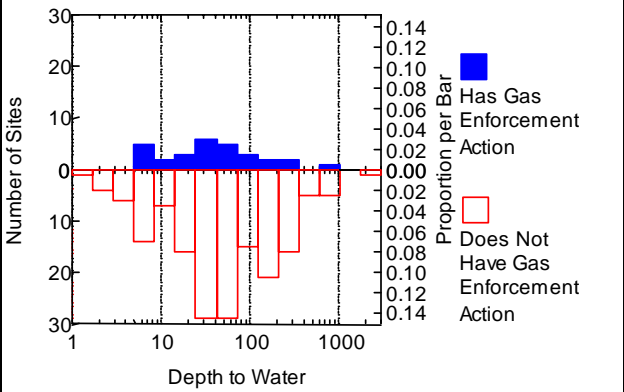
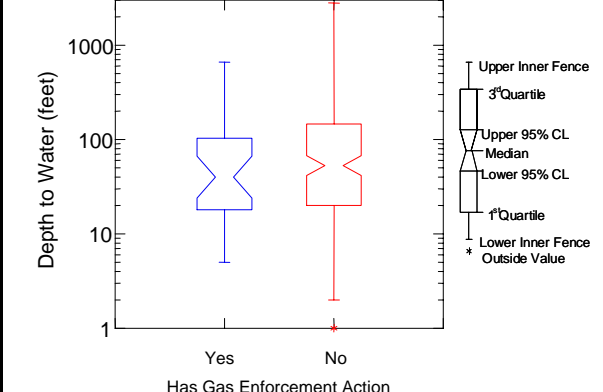
Assessment of Individual MSW Landfill Site Characteristics By Gas Enforcement Action Status

Results statements in this appendix are based on the study's Task 2 database inventory, which contains data on the 224 MSW landfills studied.

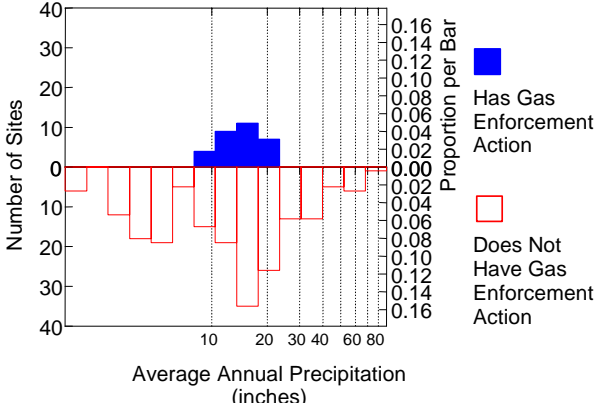
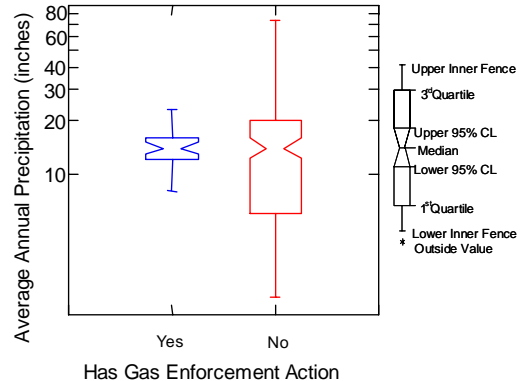
Site Characteristic (Independent Variable)	<div>Owner Type</div> <div>Value and Number of Landfills</div> <div>Public: 168</div> <div>Private: 56</div>																														
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: “Has Gas Enforcement Action” or “Does Not Have Gas Enforcement Action”)</div> <div>Summary Table Results—Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Independent Variable Reference Value</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Private</td><td>Public</td><td>0.317</td><td>1.522</td><td>3.464</td><td>0.668</td></tr></table> <div><div><div>Number of Sites in Each Gas Enforcement Action Category by Owner Type</div><table><tr><th>Owner Type</th><th>Has Gas Enforcement Action</th><th>Does Not Have Gas Enforcement Action</th></tr><tr><td>Private</td><td>10</td><td>46</td></tr><tr><td>Public</td><td>21</td><td>147</td></tr></table></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Owner Type</div><table><tr><th>Owner Type</th><th>Has Gas Enforcement Action (%)</th><th>Does Not Have Gas Enforcement Action (%)</th></tr><tr><td>Private</td><td>32</td><td>24</td></tr><tr><td>Public</td><td>76</td><td>68</td></tr></table></div></div>	Independent Variable Category	Independent Variable Reference Value	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Private	Public	0.317	1.522	3.464	0.668	Owner Type	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	Private	10	46	Public	21	147	Owner Type	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)	Private	32	24	Public	76	68
Independent Variable Category	Independent Variable Reference Value	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																										
Private	Public	0.317	1.522	3.464	0.668																										
Owner Type	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																													
Private	10	46																													
Public	21	147																													
Owner Type	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)																													
Private	32	24																													
Public	76	68																													
Variable Type for Statistical Analysis	Categorical Independent Variable																														
Results Statement	Owner type does not increase or decrease the likelihood that a site is in the category “Has Gas Enforcement Action.”																														

Site Characteristic (Independent Variable)	<div>Physical Setting</div> <div>Value and Number of Landfills</div> <div>Inland: 119 Desert: 58 Coastal: 17 Alpine: 13 High Desert: 9 Estuarine: 8</div>																																				
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Has Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>High Desert</td><td>Inland</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr><tr><td>Desert</td><td>Inland</td><td>0.012</td><td>6.708</td><td>29.525</td><td>1.524</td></tr><tr><td>Alpine</td><td>Inland</td><td>0.731</td><td>1.318</td><td>6.358</td><td>0.273</td></tr><tr><td>Coastal</td><td>Inland</td><td>0.457</td><td>1.797</td><td>8.415</td><td>0.384</td></tr><tr><td>Estuarine</td><td>Inland</td><td>0.697</td><td>0.719</td><td>3.794</td><td>0.136</td></tr></table> <div><div><div>Number of Sites in Each Gas Enforcement Action Category by Physical Setting</div></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Physical Setting</div></div></div>	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	High Desert	Inland	NA	NA	NA	NA	Desert	Inland	0.012	6.708	29.525	1.524	Alpine	Inland	0.731	1.318	6.358	0.273	Coastal	Inland	0.457	1.797	8.415	0.384	Estuarine	Inland	0.697	0.719	3.794	0.136
Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																
High Desert	Inland	NA	NA	NA	NA																																
Desert	Inland	0.012	6.708	29.525	1.524																																
Alpine	Inland	0.731	1.318	6.358	0.273																																
Coastal	Inland	0.457	1.797	8.415	0.384																																
Estuarine	Inland	0.697	0.719	3.794	0.136																																
Variable Type for Statistical Analysis	Categorical Independent Variable																																				
Results Statement	It is approximately 6.7 times less likely that a desert site is in the category “Has Gas Enforcement Action” than an inland site. No other physical settings increase or decrease the likelihood that a site is in the category “Has Gas Enforcement Action”. Based on the available data, none of the high desert sites are in the category “Has Gas Enforcement Action.”																																				

Site Characteristic (Independent Variable)	<div>Social Setting</div> <div>Value and Number of Landfills</div> <div>Rural: 139</div> <div>Urban: 71</div> <div>Suburban: 14</div>																																											
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Urban</td><td>Rural</td><td>0.026</td><td>2.405</td><td>5.208</td><td>1.111</td></tr><tr><td>Suburban</td><td>Rural</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr></table> <div><div><div>Number of Sites in Each Gas Enforcement Action Category by Social Setting</div><table><thead><tr><th>Social Setting</th><th>Has Gas Enforcement Action</th><th>Does Not Have Gas Enforcement Action</th></tr></thead><tbody><tr><td>Rural</td><td>15</td><td>124</td></tr><tr><td>Suburban</td><td>0</td><td>14</td></tr><tr><td>Urban</td><td>16</td><td>55</td></tr></tbody></table></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Social Setting</div><table><thead><tr><th>Social Setting</th><th>Has Gas Enforcement Action</th><th>Does Not Have Gas Enforcement Action</th></tr></thead><tbody><tr><td>Rural</td><td>48</td><td>64</td></tr><tr><td>Suburban</td><td>0</td><td>7</td></tr><tr><td>Urban</td><td>52</td><td>28</td></tr></tbody></table></div></div>		Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Urban	Rural	0.026	2.405	5.208	1.111	Suburban	Rural	NA	NA	NA	NA	Social Setting	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	Rural	15	124	Suburban	0	14	Urban	16	55	Social Setting	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	Rural	48	64	Suburban	0	7	Urban	52	28
Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																							
Urban	Rural	0.026	2.405	5.208	1.111																																							
Suburban	Rural	NA	NA	NA	NA																																							
Social Setting	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																																										
Rural	15	124																																										
Suburban	0	14																																										
Urban	16	55																																										
Social Setting	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																																										
Rural	48	64																																										
Suburban	0	7																																										
Urban	52	28																																										
Variable Type for Statistical Analysis	Categorical Independent Variable																																											
Results Statement	It is approximately 2.4 times more likely that an urban site is in the category “Has Gas Enforcement Action” than a rural site. None of the suburban sites are in the category “Has Gas Enforcement Action.”																																											

Site Characteristic (Independent Variable)	Minimum Depth to Underlying Groundwater Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</p> <p style="text-align: center;">Summary Table of Results – Logistic Regression (Kruskal-Wallis Analysis of Variance)</p> <table border="1" data-bbox="358 575 1469 672"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Minimum Depth to Underlying Groundwater</td><td>0.984</td></tr> </tbody> </table> <div style="display: flex; justify-content: space-around;"> <div data-bbox="302 777 922 1381"> <p>Log-Scale Frequency Diagram of Depth to Water by Gas Enforcement Action Category</p>  </div> <div data-bbox="922 777 1523 1381"> <p>Box-and-Whisker Plot of Depth to Water by Gas Enforcement Action Category</p>  </div> </div>	Independent Variable Category	Probability	Minimum Depth to Underlying Groundwater	0.984
Independent Variable Category	Probability				
Minimum Depth to Underlying Groundwater	0.984				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is not a statistically significant difference in depth to water whether a site is in the category “Has Gas Enforcement Action” or “Does Not Have Gas Enforcement Action.”				

Site Characteristic (Independent Variable)	<div>Underlying Geologic Material</div> <div>Value and Number of Landfills</div> <div>Sand and/or Gravel: 95 Silts/Clays: 62 Sedimentary Rock: 51 Igneous Rock: 16</div>																									
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>Sand and/or Gravel</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr><tr><td>Sedimentary Rock</td><td>Sand and/or Gravel</td><td>0.483</td><td>1.421</td><td>3.793</td><td>0.532</td></tr><tr><td>Silts/Clays</td><td>Sand and/or Gravel</td><td>0.182</td><td>1.833</td><td>4.462</td><td>0.753</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Igneous Rock	Sand and/or Gravel	NA	NA	NA	NA	Sedimentary Rock	Sand and/or Gravel	0.483	1.421	3.793	0.532	Silts/Clays	Sand and/or Gravel	0.182	1.833	4.462	0.753
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																					
Igneous Rock	Sand and/or Gravel	NA	NA	NA	NA																					
Sedimentary Rock	Sand and/or Gravel	0.483	1.421	3.793	0.532																					
Silts/Clays	Sand and/or Gravel	0.182	1.833	4.462	0.753																					
	<div>Number of Sites in Each Gas Enforcement Action Category by Underlying Geologic Material</div>	<div>Percent of Sites in Each Gas Enforcement Action Category by Underlying Geologic Material</div>																								
Variable Type for Statistical Analysis	Categorical Independent Variable																									
Results Statement	The underlying geologic material does not increase or decrease the likelihood that a site is in the category “Has Gas Enforcement Action.” None of the igneous rock sites are in the category “Has Gas Enforcement Action.”																									

Site Characteristic (Independent Variable)	Average Annual Precipitation Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1" data-bbox="358 575 1469 711"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Average Annual Precipitation</td><td>0.384</td></tr> </tbody> </table> <div style="display: flex; justify-content: space-around;"> <div data-bbox="305 819 922 1432"> <p style="text-align: center;">Log-Scale Frequency Diagram of Average Annual Precipitation by Enforcement Action Category</p>  </div> <div data-bbox="922 819 1529 1432"> <p style="text-align: center;">Box-and-Whisker Plot of Average Annual Precipitation by Enforcement Action Category</p>  </div> </div>	Independent Variable Category	Probability	Average Annual Precipitation	0.384
Independent Variable Category	Probability				
Average Annual Precipitation	0.384				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is not a statistically significant difference in average annual precipitation whether a site is in the category "Has Gas Enforcement Action" or "Does Not Have Gas Enforcement Action."				

Site Characteristic (Independent Variable)	<div>Landfill Gas Collection System</div> <div>Value and Number of Landfills</div> <div>Yes: 103 No: 121</div>													
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Yes (have landfill gas monitoring)</td><td>No (do not have landfill gas monitoring)</td><td>0.004</td><td>3.38</td><td>7.725</td><td>1.479</td></tr></table>		Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Yes (have landfill gas monitoring)	No (do not have landfill gas monitoring)	0.004	3.38	7.725	1.479
	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Yes (have landfill gas monitoring)	No (do not have landfill gas monitoring)	0.004	3.38	7.725	1.479								
<div><div><div>Number of Sites in Each Gas Enforcement Action Category by Landfill Gas Collection System</div></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Landfill Gas Collection System</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	It is approximately 3.4 times more likely that sites with landfill gas collection systems are in the category “Has Gas Enforcement Action” than those that do not have landfill gas collection systems.													

Site Characteristic (Independent Variable)	Landfill Size (Permitted Disposal Area) Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</p> <p>Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1" data-bbox="358 535 1469 634"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Permitted Disposal Area</td><td>0.199</td></tr> </tbody> </table> <div data-bbox="305 741 922 1432"> <p>Log-Scale Frequency Diagram of Permitted Disposal Area By Gas Enforcement Action Category</p> </div> <div data-bbox="922 741 1529 1432"> <p>Box-and-Whisker Plot of Permitted Disposal Area by Gas Enforcement Area Category</p> </div>	Independent Variable Category	Probability	Permitted Disposal Area	0.199
Independent Variable Category	Probability				
Permitted Disposal Area	0.199				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is no statistically significant difference between the permitted disposal area of landfills that are in the category “Has Gas Enforcement Action” and of those that are in the category “Does Not Have Gas Enforcement Action.”				

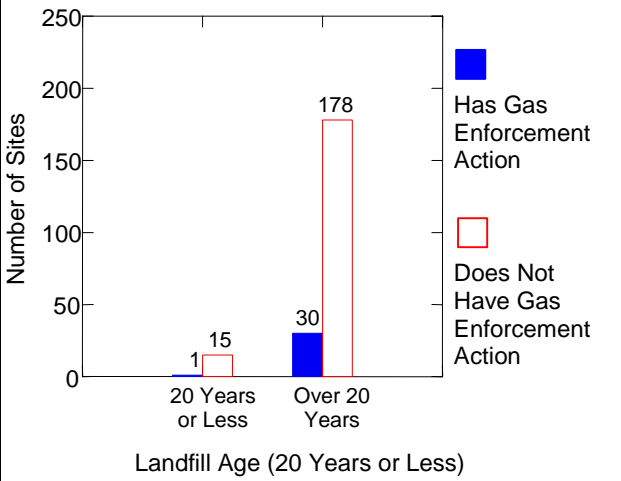
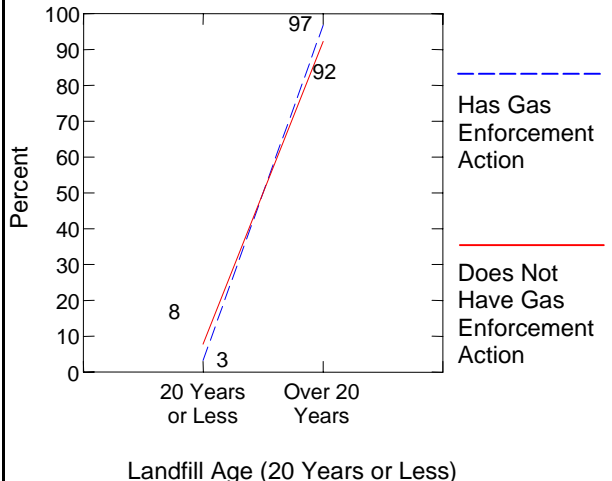
Site Characteristic (Independent Variable)	<div>Liner Type (Whole Site)</div> <div>Value and Number of Landfills</div> <div>Completely Subtitle-D* or Subtitle-D Alternative: 4</div> <div>Fully Lined, Partially non-Subtitle-D or non-Subtitle-D Alternative: 12</div> <div>Partially Unlined: 70</div> <div>Fully Unlined: 138</div> <div>*Also referred to as “Sub-D.”</div>																									
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Completely Subtitle-D or Subtitle-D alternative</td><td>Fully Unlined</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr><tr><td>Fully Lined, partially non-Subtitle-D or non-Subtitle-D alternative</td><td>Fully Unlined</td><td>0.109</td><td>3.205</td><td>13.34</td><td>0.77</td></tr><tr><td>Partially Unlined</td><td>Fully Unlined</td><td>0.017</td><td>2.67</td><td>5.994</td><td>1.19</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Subtitle-D or Subtitle-D alternative	Fully Unlined	NA	NA	NA	NA	Fully Lined, partially non-Subtitle-D or non-Subtitle-D alternative	Fully Unlined	0.109	3.205	13.34	0.77	Partially Unlined	Fully Unlined	0.017	2.67	5.994	1.19
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																				
Completely Subtitle-D or Subtitle-D alternative	Fully Unlined	NA	NA	NA	NA																					
Fully Lined, partially non-Subtitle-D or non-Subtitle-D alternative	Fully Unlined	0.109	3.205	13.34	0.77																					
Partially Unlined	Fully Unlined	0.017	2.67	5.994	1.19																					
	<div>Number of Sites in Each Gas Enforcement Action Category by Liner Type (Whole Site)</div>	<div>Percent of Sites in Each Gas Enforcement Action Category by Liner Type (Whole Site)</div>																								
Variable Type for Statistical Analysis	Categorical Independent Variable																									
Results Statement	It is approximately 2.7 times more likely that a partially unlined site is in the category “Has Gas Enforcement Action” than a site that is fully unlined. No other liner category increases or decreases the likelihood that a site is in the category “Has Gas Enforcement Action” relative to fully unlined sites. Based on the available data, none of the completely Sub-D or Sub-D alternative sites are in the category “Has Gas Enforcement Action.”																									

Site Characteristic (Independent Variable)	<div>Cover Type (Whole Site)</div> <div>Value and Number of Landfills</div> <div>Completely Covered: 48 Partially Uncovered: 30 Completely Uncovered: 146</div>																																				
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Covered</td><td>Fully Uncovered</td><td>0.0563</td><td>0.1375</td><td>1.055</td><td>0.0179</td></tr><tr><td>Partially Uncovered</td><td>Fully Uncovered</td><td>0.00092</td><td>4.63</td><td>11.465</td><td>1.871</td></tr></table> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Has Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Covered</td><td>Fully Uncovered</td><td>0.0563</td><td>7.273</td><td>55.804</td><td>0.948</td></tr><tr><td>Partially Uncovered</td><td>Fully Uncovered</td><td>0.00092</td><td>0.216</td><td>0.534</td><td>0.087</td></tr></table>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Covered	Fully Uncovered	0.0563	0.1375	1.055	0.0179	Partially Uncovered	Fully Uncovered	0.00092	4.63	11.465	1.871	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Covered	Fully Uncovered	0.0563	7.273	55.804	0.948	Partially Uncovered	Fully Uncovered	0.00092	0.216	0.534	0.087
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																
Completely Covered	Fully Uncovered	0.0563	0.1375	1.055	0.0179																																
Partially Uncovered	Fully Uncovered	0.00092	4.63	11.465	1.871																																
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																
Completely Covered	Fully Uncovered	0.0563	7.273	55.804	0.948																																
Partially Uncovered	Fully Uncovered	0.00092	0.216	0.534	0.087																																

	<div data-bbox="404 170 820 260" data-label="Caption"> <p>Number of Sites in Each Gas Enforcement Action Category by Cover Type (Whole Site)</p> </div> <div data-bbox="316 289 891 789" data-label="Figure"> <table border="1"> <thead> <tr> <th>Cover Type (Whole Site)</th> <th>Has Gas Enforcement Action</th> <th>Does Not Have Gas Enforcement Action</th> </tr> </thead> <tbody> <tr> <td>Completely Covered</td> <td>1</td> <td>47</td> </tr> <tr> <td>Completely Uncovered</td> <td>19</td> <td>127</td> </tr> <tr> <td>Partially Uncovered</td> <td>11</td> <td>19</td> </tr> </tbody> </table> </div> <div data-bbox="1016 170 1432 260" data-label="Caption"> <p>Percent of Sites in Each Gas Enforcement Action Category by Cover Type (Whole Site)</p> </div> <div data-bbox="924 296 1534 800" data-label="Figure"> <table border="1"> <thead> <tr> <th>Cover Type (Whole Site)</th> <th>Has Gas Enforcement Action</th> <th>Does Not Have Gas Enforcement Action</th> </tr> </thead> <tbody> <tr> <td>Completely Covered</td> <td>3</td> <td>25</td> </tr> <tr> <td>Completely Uncovered</td> <td>61</td> <td>66</td> </tr> <tr> <td>Partially Uncovered</td> <td>35</td> <td>8</td> </tr> </tbody> </table> </div>	Cover Type (Whole Site)	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	Completely Covered	1	47	Completely Uncovered	19	127	Partially Uncovered	11	19	Cover Type (Whole Site)	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	Completely Covered	3	25	Completely Uncovered	61	66	Partially Uncovered	35	8	
Cover Type (Whole Site)	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																								
Completely Covered	1	47																								
Completely Uncovered	19	127																								
Partially Uncovered	11	19																								
Cover Type (Whole Site)	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																								
Completely Covered	3	25																								
Completely Uncovered	61	66																								
Partially Uncovered	35	8																								
Variable Type for Statistical Analysis	Categorical Independent Variable																									
Results Statement	<p>It is approximately 4.6 times more likely that a partially uncovered site is in the category “Has Gas Enforcement Action” than a fully uncovered site. At a 95 percent significance level, the cover type does not increase or decrease the likelihood that a site is in the category “Has Gas Enforcement Action.” Under a 90 percent significance level, the results indicate a completely covered site is approximately 7.3 times less likely than a completely uncovered site to be in the category “Has Gas Enforcement Action.”</p>																									

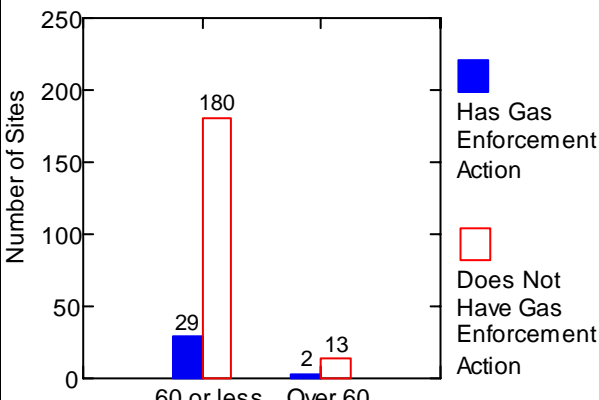
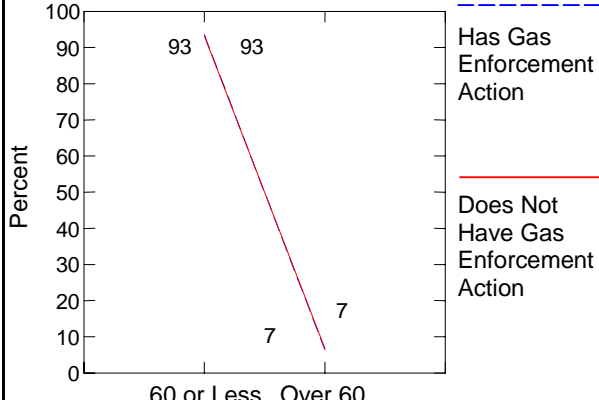
Site Characteristic (Independent Variable)	Landfill Age Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1" data-bbox="358 596 1469 730"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Landfill Age</td><td>0.963</td></tr> </tbody> </table> <div style="display: flex; justify-content: space-around;"> <div data-bbox="302 835 922 1507"> <p>Log-Scale Frequency Diagram of Landfill Age By Gas Enforcement Action Category</p> </div> <div data-bbox="922 835 1523 1507"> <p>Box-and-Whisker Plot of Age of Site by Gas Enforcement Action Category</p> </div> </div>	Independent Variable Category	Probability	Landfill Age	0.963
Independent Variable Category	Probability				
Landfill Age	0.963				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is no statistically significant difference in age between landfills that are in the category “Has Gas Enforcement Action” and those in the category “Does Not Have Gas Enforcement Action.”				

Site Characteristic (Independent Variable)	<div>Landfill Age (Construction Before/During 1984 or After 1984)</div> <div>Value and Number of Landfills</div> <div>Construction Before/During 1984: 209</div> <div>Construction After 1984: 15</div>													
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Construction date after 1984</td><td>Construction date before/during 1984</td><td>0.4183</td><td>.4262</td><td>3.362</td><td>0.054</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Construction date after 1984	Construction date before/during 1984	0.4183	.4262	3.362	0.054
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Construction date after 1984	Construction date before/during 1984	0.4183	.4262	3.362	0.054								
<div><div><div>Number of Sites in Each Gas Enforcement Action Category by Construction Period</div></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Construction Period</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether a site was built before/during 1984 or after 1984 does not increase or decrease the likelihood that it is in the category “Has Gas Enforcement Action.”													

Site Characteristic (Independent Variable)	<div>Landfill Age (20 Years or Less)</div> <div>Value and Number of Landfills</div> <div>Landfill age 20 years or less: 16</div> <div>Landfill age greater than 20 years: 208</div>																															
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Age of site 20 years or less</td><td>Age of site greater than 20 years</td><td>0.3778</td><td>0.3956</td><td>3.106</td><td>0.0503</td></tr></tbody></table> <div><div><div>Number of Sites in Each Gas Enforcement Action Category by Landfill Age (20 Years or Less)</div><table><caption>Data for Number of Sites in Each Gas Enforcement Action Category by Landfill Age</caption><thead><tr><th>Landfill Age</th><th>Has Gas Enforcement Action</th><th>Does Not Have Gas Enforcement Action</th></tr></thead><tbody><tr><td>20 Years or Less</td><td>1</td><td>15</td></tr><tr><td>Over 20 Years</td><td>30</td><td>178</td></tr></tbody></table></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Landfill Age (20 Years or Less)</div><table><caption>Data for Percent of Sites in Each Gas Enforcement Action Category by Landfill Age</caption><thead><tr><th>Landfill Age</th><th>Has Gas Enforcement Action (%)</th><th>Does Not Have Gas Enforcement Action (%)</th></tr></thead><tbody><tr><td>20 Years or Less</td><td>8</td><td>92</td></tr><tr><td>Over 20 Years</td><td>3</td><td>97</td></tr></tbody></table></div></div>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Age of site 20 years or less	Age of site greater than 20 years	0.3778	0.3956	3.106	0.0503	Landfill Age	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	20 Years or Less	1	15	Over 20 Years	30	178	Landfill Age	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)	20 Years or Less	8	92	Over 20 Years	3	97
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																											
Age of site 20 years or less	Age of site greater than 20 years	0.3778	0.3956	3.106	0.0503																											
Landfill Age	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																														
20 Years or Less	1	15																														
Over 20 Years	30	178																														
Landfill Age	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)																														
20 Years or Less	8	92																														
Over 20 Years	3	97																														
Variable Type for Statistical Analysis	Dichotomous Independent Variable																															
Results Statement	Whether or not a site is in the age bracket of 20 years or less does not increase or decrease the likelihood of its being in the category “Has Gas Enforcement Action.”																															

Site Characteristic (Independent Variable)	<div>Landfill Age (21–40 Years)</div> <div>Value and Number of Landfills</div> <div>Landfill age 21–40 years: 143</div> <div>Other: 81</div>													
Environmental Performance	<div>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Landfill Age 21–40 Years</td><td>Other</td><td>0.6265</td><td>1.222</td><td>2.741</td><td>0.545</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill Age 21–40 Years	Other	0.6265	1.222	2.741	0.545
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Landfill Age 21–40 Years	Other	0.6265	1.222	2.741	0.545								
<div><div><div>Number of Sites in Each Gas Enforcement Action Category by Landfill Age (21–40 Years)</div></div><div><div>Percent of Sites in Each Gas Enforcement Action Category by Landfill Age (21–40 Years)</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether or not a site is between 21 and 40 years old does not increase or decrease the likelihood of its being in the category “Has Gas Enforcement Action.”													

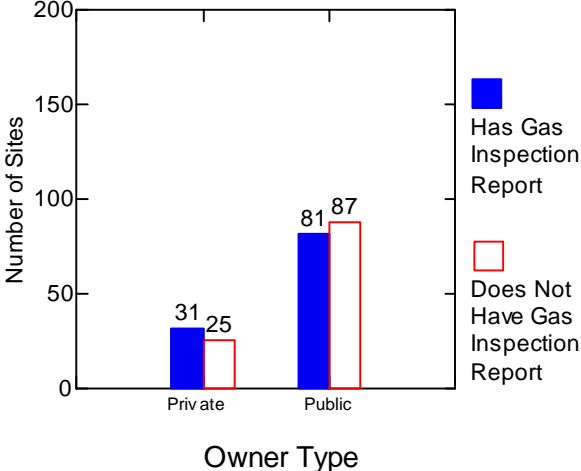
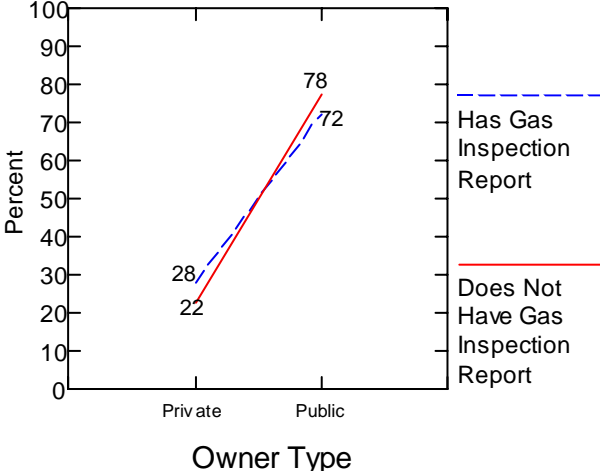
Site Characteristic (Independent Variable)	<h2>Landfill Age (41–60 Years)</h2> <p>Value and Number of Landfills</p> <p>Landfill Age 41–60 years: 50 Other: 174</p>																															
Environmental Performance	<p>Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)</p> <p>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)</p> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Landfill Age 41–60 years</td><td>Other</td><td>0.9702</td><td>1.017</td><td>2.522</td><td>0.411</td></tr></tbody></table> <div><div><p>Number of Sites in Each Gas Enforcement Action Category by Landfill Age (41–60 Years)</p><table><thead><tr><th>Landfill Age</th><th>Has Gas Enforcement Action</th><th>Does Not Have Gas Enforcement Action</th></tr></thead><tbody><tr><td>41–60 Years</td><td>7</td><td>43</td></tr><tr><td>Other</td><td>24</td><td>150</td></tr></tbody></table></div><div><p>Percent of Sites in Each Gas Enforcement Action Category by Landfill Age (41–60 Years)</p><table><thead><tr><th>Landfill Age</th><th>Has Gas Enforcement Action (%)</th><th>Does Not Have Gas Enforcement Action (%)</th></tr></thead><tbody><tr><td>41–60 Years</td><td>22</td><td>78</td></tr><tr><td>Other</td><td>22</td><td>78</td></tr></tbody></table></div></div>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill Age 41–60 years	Other	0.9702	1.017	2.522	0.411	Landfill Age	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action	41–60 Years	7	43	Other	24	150	Landfill Age	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)	41–60 Years	22	78	Other	22	78
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																											
Landfill Age 41–60 years	Other	0.9702	1.017	2.522	0.411																											
Landfill Age	Has Gas Enforcement Action	Does Not Have Gas Enforcement Action																														
41–60 Years	7	43																														
Other	24	150																														
Landfill Age	Has Gas Enforcement Action (%)	Does Not Have Gas Enforcement Action (%)																														
41–60 Years	22	78																														
Other	22	78																														
Variable Type for Statistical Analysis	Dichotomous Independent Variable																															
Results Statement	Whether or not a site is 41–60 years old does not increase or decrease the likelihood of its being in the category “Has Gas Enforcement Action.”																															

Site Characteristic (Independent Variable)	Landfill Age (Greater Than 60 Years) Value and Number of Landfills Landfill Age Greater Than 60 Years: 15 Landfill Age 60 Years or Less: 209												
Environmental Performance	Dependent Variable: Has Gas Enforcement Action (Binary Values: Has Gas Enforcement Action or Does Not Have Gas Enforcement Action)												
	Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Enforcement Action”)												
	<table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Landfill Age Greater Than 60 Years</td><td>Landfill Age Less Than or Equal To 60 years</td><td>0.9532</td><td>0.9549</td><td>4.452</td><td>0.2048</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill Age Greater Than 60 Years	Landfill Age Less Than or Equal To 60 years	0.9532	0.9549	4.452
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
Landfill Age Greater Than 60 Years	Landfill Age Less Than or Equal To 60 years	0.9532	0.9549	4.452	0.2048								
	<div><p>Number of Sites in Each Gas Enforcement Action Category by Landfill Age (Greater Than 60 Years)</p><p>Landfill Age (Greater Than 60 Years)</p></div>	<div><p>Percent of Sites in Each Gas Enforcement Action Category by Landfill Age (Greater Than 60 Years)</p><p>Landfill Age (Greater Than 60 Years)</p></div>											
	Variable Type for Statistical Analysis	Dichotomous Independent Variable											
Results Statement	Whether or not a site is over 60 years old does not increase or decrease the likelihood that of its being in the category “Has Gas Enforcement Action.”												

Appendix B-3

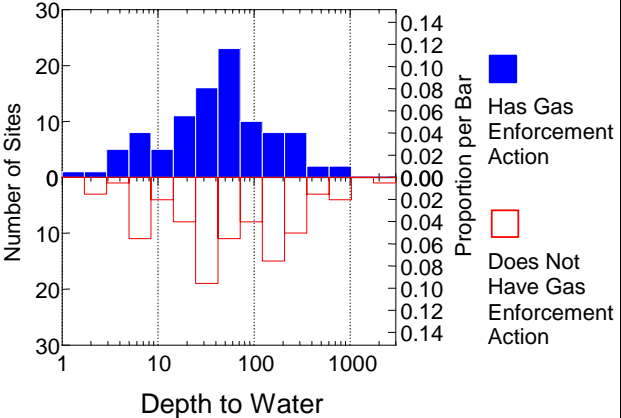
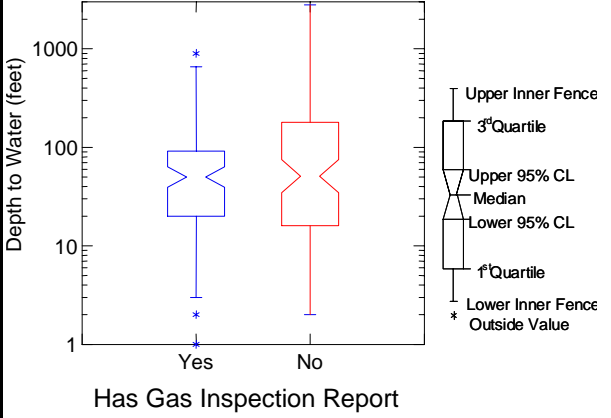
Assessment of Individual MSW Landfill Site Characteristics By Gas Inspection Report Status

Results statements in this appendix are based on the study's Task 2 database inventory,
which contains data on the 224 MSW landfills studied.

Site Characteristic (Independent Variable)	<div>Owner Type</div> <div>Value and Number of Landfills</div> <div>Public: 168</div> <div>Private: 56</div>																														
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Private</td><td>Public</td><td>0.355</td><td>1.33</td><td>2.445</td><td>0.725</td></tr></table> <div><div><div>Number of Sites in Each Gas Inspection Report Category by Owner Type</div><table><caption>Data for Number of Sites</caption><thead><tr><th>Owner Type</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>Private</td><td>31</td><td>25</td></tr><tr><td>Public</td><td>81</td><td>87</td></tr></tbody></table></div><div><div>Percent of Sites in Each Gas Inspection Report Category by Owner Type</div><table><caption>Data for Percent of Sites</caption><thead><tr><th>Owner Type</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>Private</td><td>28</td><td>22</td></tr><tr><td>Public</td><td>78</td><td>72</td></tr></tbody></table></div></div>	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Private	Public	0.355	1.33	2.445	0.725	Owner Type	Has Gas Inspection Report	Does Not Have Gas Inspection Report	Private	31	25	Public	81	87	Owner Type	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	Private	28	22	Public	78	72
Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																										
Private	Public	0.355	1.33	2.445	0.725																										
Owner Type	Has Gas Inspection Report	Does Not Have Gas Inspection Report																													
Private	31	25																													
Public	81	87																													
Owner Type	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																													
Private	28	22																													
Public	78	72																													
Variable Type for Statistical Analysis	Categorical Independent Variable																														
Results Statement	Owner type does not increase or decrease the likelihood of a site’s being in the category “Has Gas Inspection Report.”																														

Site Characteristic (Independent Variable)	<h1>Physical Setting</h1> <p>Value and Number of Landfills</p> <div><div>Inland: 119</div><div>Alpine: 13</div><div>Desert: 58</div><div>High Desert: 9</div><div>Coastal: 17</div><div>Estuarine: 8</div></div>																																					
Environmental Performance	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <p>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Has Gas Inspection Report”)</p> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>High Desert</td><td>Inland</td><td>0.926</td><td>1.067</td><td>4.173</td><td>0.273</td></tr><tr><td>Desert</td><td>Inland</td><td>0.010</td><td>2.349</td><td>4.486</td><td>1.230</td></tr><tr><td>Alpine</td><td>Inland</td><td>0.012</td><td>7.334</td><td>34.542</td><td>1.557</td></tr><tr><td>Coastal</td><td>Inland</td><td>0.896</td><td>0.933</td><td>2.619</td><td>0.333</td></tr><tr><td>Estuarine</td><td>Inland</td><td>0.333</td><td>0.444</td><td>2.293</td><td>0.086</td></tr></table>		Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	High Desert	Inland	0.926	1.067	4.173	0.273	Desert	Inland	0.010	2.349	4.486	1.230	Alpine	Inland	0.012	7.334	34.542	1.557	Coastal	Inland	0.896	0.933	2.619	0.333	Estuarine	Inland	0.333	0.444	2.293	0.086
	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																
	High Desert	Inland	0.926	1.067	4.173	0.273																																
Desert	Inland	0.010	2.349	4.486	1.230																																	
Alpine	Inland	0.012	7.334	34.542	1.557																																	
Coastal	Inland	0.896	0.933	2.619	0.333																																	
Estuarine	Inland	0.333	0.444	2.293	0.086																																	
<div><div><h2>Number of Sites in Each Gas Inspection Report Category by Physical Setting</h2></div><div><h2>Percent of Sites in Each Gas Inspection Report Category by Physical Setting</h2></div></div>																																						
Variable Type for Statistical Analysis	Categorical Independent Variable																																					
Results Statement	It is approximately 2.3 times less likely that a desert site is in the category “Has Gas Inspection Report” than an inland site. It is approximately 7.3 times less likely that an alpine site is in the category “Has Gas Inspection Report” than an inland site. No other physical settings increase or																																					

	decrease the likelihood that a site is in the category “Has Gas Inspection Report.”																		
Site Characteristic (Independent Variable)	<div><div>Social Setting</div><div>Value and Number of Landfills</div><div>Rural: 139 Urban: 71 Suburban: 14</div></div>																		
Environmental Performance	<div><div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div><div><div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div><table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Urban</td><td>Rural</td><td>0.00017</td><td>3.20415</td><td>5.87354</td><td>1.74793</td></tr><tr><td>Suburban</td><td>Rural</td><td>0.89338</td><td>1.07895</td><td>3.2777</td><td>0.35517</td></tr></table></div><div><div><div>Number of Sites in Each Gas Inspection Report Category by Social Setting</div></div><div><div>Percent of Sites in Each Gas Inspection Report Category by Social Setting</div></div></div></div>	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Urban	Rural	0.00017	3.20415	5.87354	1.74793	Suburban	Rural	0.89338	1.07895	3.2777	0.35517
Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio														
Urban	Rural	0.00017	3.20415	5.87354	1.74793														
Suburban	Rural	0.89338	1.07895	3.2777	0.35517														
Variable Type for Statistical Analysis	Categorical Independent Variable																		
Results Statement	It is approximately 3.2 times more likely that an urban site is in the category “Has Gas Inspection Report” than a rural site. The suburban setting does not increase or decrease the likelihood that a site is in the category “Has Gas Inspection Report.”																		

Site Characteristic (Independent Variable)	Minimum Depth to Underlying Groundwater Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <p style="text-align: center;">Summary Table of Results Kruskal-Wallis Analysis of Variance</p> <table border="1" data-bbox="358 579 1469 716"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Minimum Depth to Underlying Groundwater</td><td>0.573</td></tr> </tbody> </table> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div data-bbox="305 825 922 1470"> <p style="text-align: center;">Log-Scale Frequency Diagram of Depth to Water by Gas Inspection Report Category</p>  </div> <div data-bbox="922 825 1529 1470"> <p style="text-align: center;">Box-and-Whisker Plot of Depth to Water by Gas Inspection Report Category</p>  </div> </div>	Independent Variable Category	Probability	Minimum Depth to Underlying Groundwater	0.573
Independent Variable Category	Probability				
Minimum Depth to Underlying Groundwater	0.573				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is not a statistically significant difference in depth to water whether a site is in the category “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report.”				

Site Characteristic (Independent Variable)	<h2>Underlying Geologic Material</h2> <p>Value and Number of Landfills</p> <p>Sand and/or Gravel: 95 Silts/Clays: 62 Sedimentary Rock: 51 Igneous Rock: 16</p>																														
Environmental Performance	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <p>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</p> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>Sand and/or Gravel</td><td>0.910</td><td>0.941</td><td>2.734</td><td>0.324</td></tr><tr><td>Sedimentary Rock</td><td>Sand and/or Gravel</td><td>0.075</td><td>1.874</td><td>3.745</td><td>0.938</td></tr><tr><td>Silts/Clays</td><td>Sand and/or Gravel</td><td>0.561</td><td>1.209</td><td>2.296</td><td>0.637</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Igneous Rock	Sand and/or Gravel	0.910	0.941	2.734	0.324	Sedimentary Rock	Sand and/or Gravel	0.075	1.874	3.745	0.938	Silts/Clays	Sand and/or Gravel	0.561	1.209	2.296	0.637					
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																									
	Igneous Rock	Sand and/or Gravel	0.910	0.941	2.734	0.324																									
Sedimentary Rock	Sand and/or Gravel	0.075	1.874	3.745	0.938																										
Silts/Clays	Sand and/or Gravel	0.561	1.209	2.296	0.637																										
<div><div><h3>Number of Sites in Each Gas Inspection Report Category by Underlying Geologic Material</h3><table><caption>Data for Number of Sites Chart</caption><thead><tr><th>Geologic Material</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>7</td><td>9</td></tr><tr><td>Sand and/or Gravel</td><td>43</td><td>52</td></tr><tr><td>Sedimentary Rock</td><td>31</td><td>20</td></tr><tr><td>Silts/Clays</td><td>31</td><td>31</td></tr></tbody></table></div><div><h3>Percent of Sites in Each Gas Inspection Report Category by Underlying Geologic Material</h3><table><caption>Data for Percent of Sites Chart</caption><thead><tr><th>Geologic Material</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>8</td><td>6</td></tr><tr><td>Sand and/or Gravel</td><td>46</td><td>38</td></tr><tr><td>Sedimentary Rock</td><td>28</td><td>18</td></tr><tr><td>Silts/Clays</td><td>28</td><td>28</td></tr></tbody></table></div></div>		Geologic Material	Has Gas Inspection Report	Does Not Have Gas Inspection Report	Igneous Rock	7	9	Sand and/or Gravel	43	52	Sedimentary Rock	31	20	Silts/Clays	31	31	Geologic Material	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	Igneous Rock	8	6	Sand and/or Gravel	46	38	Sedimentary Rock	28	18	Silts/Clays	28	28
Geologic Material	Has Gas Inspection Report	Does Not Have Gas Inspection Report																													
Igneous Rock	7	9																													
Sand and/or Gravel	43	52																													
Sedimentary Rock	31	20																													
Silts/Clays	31	31																													
Geologic Material	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																													
Igneous Rock	8	6																													
Sand and/or Gravel	46	38																													
Sedimentary Rock	28	18																													
Silts/Clays	28	28																													
Variable Type for Statistical Analysis	Categorical Independent Variable																														
Results Statement	At a 95 percent significance level, the underlying geologic material does not increase or decrease the likelihood that a site is in the category “Has Gas Inspection Report.” Under a lower significance level, such as 90 percent, results indicate it is approximately 4.0 times more likely that a sedimentary rock site is in the category “Has Gas Inspection Report.”																														

	<p>results indicate it is approximately 1.9 times more likely that a sedimentary rock site is in the category “Has Gas Inspection Report” than a sand and/or gravel site.</p>				
<p>Site Characteristic (Independent Variable)</p>	<p>Average Annual Precipitation</p> <p>Value and Number of Landfills</p> <p>Continuous</p>				
<p>Environmental Performance</p>	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <div> <p>Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> <tr> <td>Annual Precipitation</td><td>0. 239</td></tr> </table> </div> <div> <div> <p>Log-Scale Frequency Diagram of Average Annual Precipitation by Gas Inspection Report Category</p> </div> <div> <p>Box-and-Whisker Plot of Average Annual Precipitation by Gas Inspection Report Category</p> </div> </div>	Independent Variable Category	Probability	Annual Precipitation	0. 239
Independent Variable Category	Probability				
Annual Precipitation	0. 239				
<p>Variable Type for Statistical Analysis</p>	<p>Continuous Independent Variable</p>				
<p>Results Statement</p>	<p>There is no statistically significant difference in average annual precipitation, whether a site is in the category “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report.”</p>				

Site Characteristic (Independent Variable)	<div>Landfill Gas Collection System</div> <div>Value and Number of Landfills</div> <div>Yes: 103</div> <div>No: 121</div>												
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Yes (has landfill gas monitoring)</td><td>No (does not have landfill gas monitoring)</td><td>0.0025</td><td>3.128</td><td>5.756</td><td>1.700</td></tr></table> <div><div><div>Number of Sites in Each Gas Inspection Report Category by Landfill Gas Collection System</div></div><div><div>Percent of Sites in Each Gas Inspection Report Category by Landfill Gas Collection System</div></div></div>	Independent Variable Category	Reference Value	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Yes (has landfill gas monitoring)	No (does not have landfill gas monitoring)	0.0025	3.128	5.756	1.700
Independent Variable Category	Reference Value	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
Yes (has landfill gas monitoring)	No (does not have landfill gas monitoring)	0.0025	3.128	5.756	1.700								
Variable Type for Statistical Analysis	Dichotomous Independent Variable												
Results Statement	It is approximately 3.1 times more likely that sites with landfill gas collection systems are in the category “Has Gas Inspection Report” than those that do not have landfill gas collection systems.												

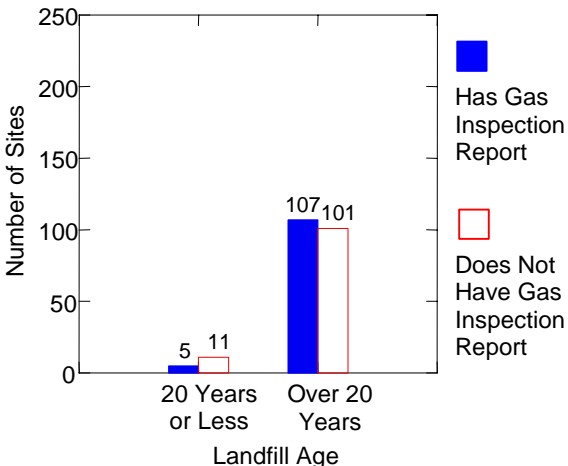
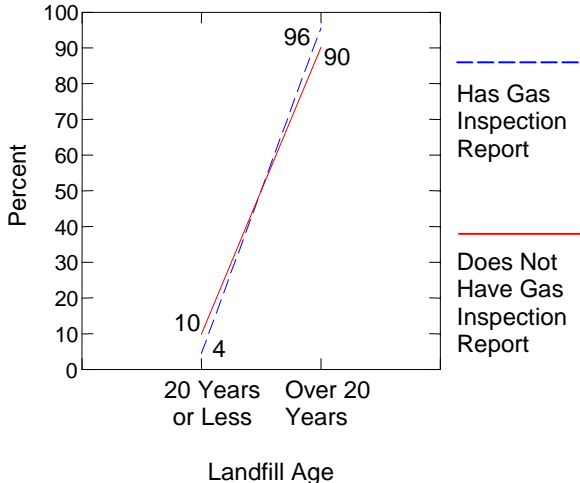
Site Characteristic (Independent Variable)	Landfill Size (Permitted Disposal Area) Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1" style="margin: auto;"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Permitted Disposal Area</td><td>0.01049</td></tr> </tbody> </table> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div data-bbox="305 785 922 1423" style="width: 45%;"> <p style="text-align: center;">Log-Scale Frequency Diagram of Permitted Disposal Area by Gas Inspection Report Category</p> </div> <div data-bbox="922 785 1529 1423" style="width: 45%;"> <p style="text-align: center;">Box-and-Whisker Plot of Permitted Disposal Area by Gas Inspection Report Category</p> </div> </div>	Independent Variable Category	Probability	Permitted Disposal Area	0.01049
Independent Variable Category	Probability				
Permitted Disposal Area	0.01049				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	The permitted disposal area is statistically different (in this case, greater) for those sites in the category “Has Gas Inspection Report.”				

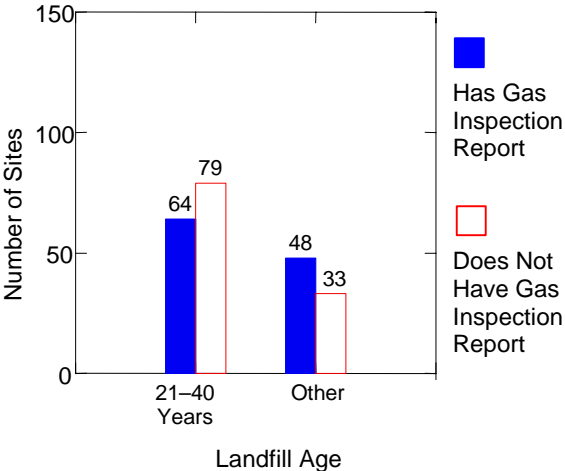
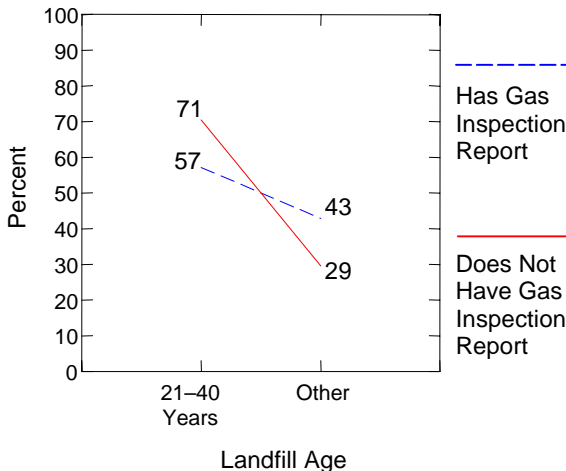
Site Characteristic (Independent Variable)	Liner Type (Whole Site) Value and Number of Landfills Completely Subtitle D* or Subtitle D Alternative: 4 Fully Lined, Partially Non-Subtitle D or Non-Subtitle D Alternative: 12 Partially Unlined: 70 Fully Unlined: 138 *Also referred to as “Sub-D.”																								
Environmental Performance	Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”) Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”) <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Sub-D or Sub-D Alternative</td><td>Fully Unlined</td><td>0.979</td><td>0.976</td><td>6.032</td><td>0.158</td></tr><tr><td>Fully Lined, Partially Non-Sub-D or Non-Sub-D-Alternative</td><td>Fully Unlined</td><td>0.240</td><td>2.05</td><td>6.785</td><td>0.619</td></tr><tr><td>Partially Unlined</td><td>Fully Unlined</td><td>0.00025</td><td>3.128</td><td>5.756</td><td>1.700</td></tr></table>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Sub-D or Sub-D Alternative	Fully Unlined	0.979	0.976	6.032	0.158	Fully Lined, Partially Non-Sub-D or Non-Sub-D-Alternative	Fully Unlined	0.240	2.05	6.785	0.619	Partially Unlined	Fully Unlined	0.00025	3.128	5.756	1.700
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																				
Completely Sub-D or Sub-D Alternative	Fully Unlined	0.979	0.976	6.032	0.158																				
Fully Lined, Partially Non-Sub-D or Non-Sub-D-Alternative	Fully Unlined	0.240	2.05	6.785	0.619																				
Partially Unlined	Fully Unlined	0.00025	3.128	5.756	1.700																				

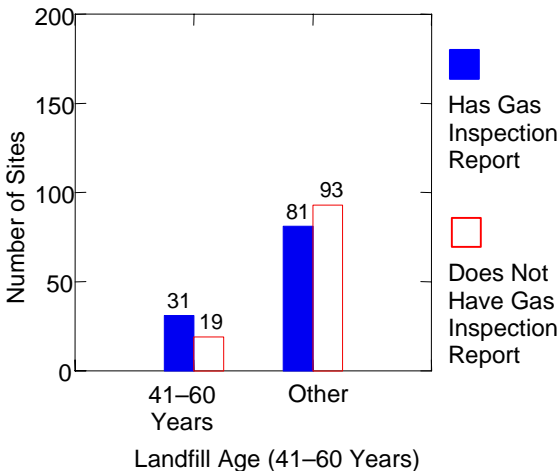
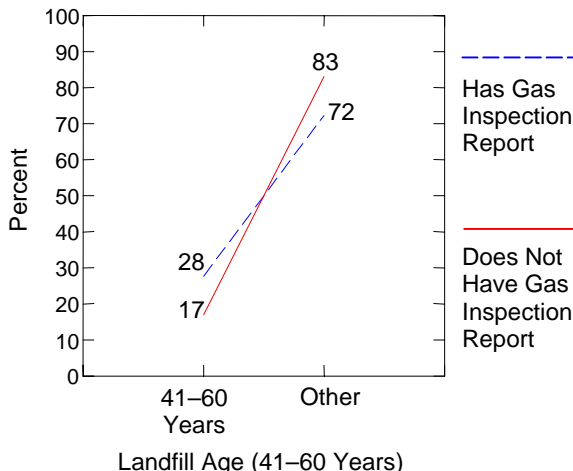
Site Characteristic (Independent Variable)	<div>Cover Type (Whole Site)</div> <div>Value and Number of Landfills</div> <div>Completely Covered: 48</div> <div>Partially Uncovered: 30</div> <div>Completely Uncovered: 146</div>																									
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Covered</td><td>Fully Uncovered</td><td>0.154</td><td>0.623</td><td>1.195</td><td>0.325</td></tr><tr><td>Partially Uncovered</td><td>Fully Uncovered</td><td>0.471</td><td>1.359</td><td>3.126</td><td>0.591</td></tr></table>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Covered	Fully Uncovered	0.154	0.623	1.195	0.325	Partially Uncovered	Fully Uncovered	0.471	1.359	3.126	0.591							
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																				
Completely Covered	Fully Uncovered	0.154	0.623	1.195	0.325																					
Partially Uncovered	Fully Uncovered	0.471	1.359	3.126	0.591																					
Environmental Performance	<div>Number of Sites in Each Gas Inspection Report Category by Cover Type</div> <table><thead><tr><th>Cover Type</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>Completely Covered</td><td>20</td><td>28</td></tr><tr><td>Fully Uncovered</td><td>76</td><td>70</td></tr><tr><td>Partially Uncovered</td><td>16</td><td>14</td></tr></tbody></table>	Cover Type	Has Gas Inspection Report	Does Not Have Gas Inspection Report	Completely Covered	20	28	Fully Uncovered	76	70	Partially Uncovered	16	14	<div>Line Plot of Percent of Sites in Each Gas Inspection Report Category by Cover Type</div> <table><thead><tr><th>Cover Type</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>Completely Covered</td><td>18</td><td>27</td></tr><tr><td>Fully Uncovered</td><td>68</td><td>63</td></tr><tr><td>Partially Uncovered</td><td>10</td><td>14</td></tr></tbody></table>	Cover Type	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	Completely Covered	18	27	Fully Uncovered	68	63	Partially Uncovered	10	14
	Cover Type	Has Gas Inspection Report	Does Not Have Gas Inspection Report																							
Completely Covered	20	28																								
Fully Uncovered	76	70																								
Partially Uncovered	16	14																								
Cover Type	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																								
Completely Covered	18	27																								
Fully Uncovered	68	63																								
Partially Uncovered	10	14																								
Variable Type for Statistical Analysis	Categorical Independent Variable																									
Results Statement	The cover type does not increase or decrease the likelihood that a site is in the category “Has Gas Inspection Report.”																									

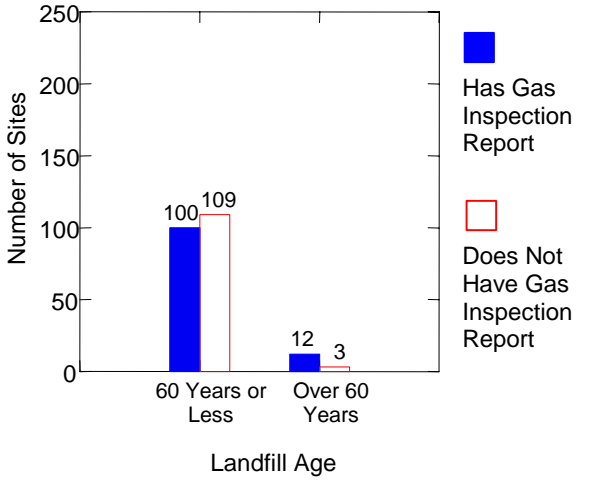
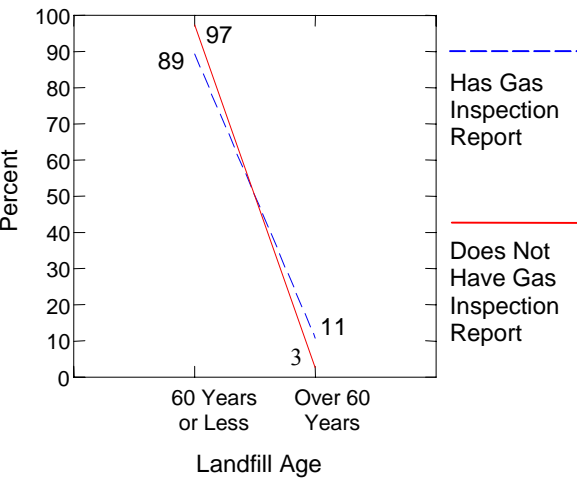
Site Characteristic (Independent Variable)	Landfill Age Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1"> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> <tr> <td>Landfill Age</td><td>0.0007</td></tr> </table> <div> <div> <p>Number of Sites in Each Gas Inspection Report Category by Construction Period</p> </div> <div> <p>Line Plot of Percent of Sites In Each Gas Inspection Report Category by Construction Period</p> </div> </div>	Independent Variable Category	Probability	Landfill Age	0.0007
Independent Variable Category	Probability				
Landfill Age	0.0007				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	Landfill age is statistically different (in this case, greater) for those sites in the category “Has Gas Inspection Report.”				

Site Characteristic (Independent Variable)	Landfill Age (Construction Before/During 1984 or After 1984) Value and Number of Landfills Construction before/during 1984: 209 Construction after 1984: 15																			
Environmental Performance	Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”) Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Has Gas Inspection Report”) <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Construction after 1984</td><td>Construction before/during 1984</td><td>0.072</td><td>2.941</td><td>9.533</td><td>0.907</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Construction after 1984	Construction before/during 1984	0.072	2.941	9.533	0.907						
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio															
Construction after 1984	Construction before/during 1984	0.072	2.941	9.533	0.907															
	Number of Sites in Each Gas Inspection Report Category by Construction Period <table><thead><tr><th>Construction Period</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>After 1984</td><td>4</td><td>11</td></tr><tr><td>Before/ During 1984</td><td>108</td><td>101</td></tr></tbody></table>	Construction Period	Has Gas Inspection Report	Does Not Have Gas Inspection Report	After 1984	4	11	Before/ During 1984	108	101	Line Plot of Percent of Sites In Each Gas Inspection Report Category by Construction Period <table><thead><tr><th>Construction Period</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>After 1984</td><td>10</td><td>4</td></tr><tr><td>Before/ During 1984</td><td>96</td><td>90</td></tr></tbody></table>	Construction Period	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	After 1984	10	4	Before/ During 1984	96	90
Construction Period	Has Gas Inspection Report	Does Not Have Gas Inspection Report																		
After 1984	4	11																		
Before/ During 1984	108	101																		
Construction Period	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																		
After 1984	10	4																		
Before/ During 1984	96	90																		
Variable Type for Statistical Analysis	Dichotomous Independent Variable																			
Results Statement	At a 95 percent significance level, whether a site was built before/during 1984 or after 1984 does not increase or decrease the likelihood of its being in the category “Has Gas Inspection Report.” Under a 90 percent significance level, results indicate it is approximately 2.9 times less likely that a site constructed after 1984 is in the category “Has Gas Inspection Report” than a site built before or during 1984.																			

Site Characteristic (Independent Variable)	<div>Landfill Age (20 Years or Less)</div> <div>Value and Number of Landfills</div> <div>Age of site less than or equal to 20 years: 16</div> <div>Age of site greater than 20 years: 208</div>													
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Landfill age 20 years or less</td><td>Age of site greater than 20 years</td><td>0.1287</td><td>0.429</td><td>1.278</td><td>0.144</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill age 20 years or less	Age of site greater than 20 years	0.1287	0.429	1.278	0.144
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
Landfill age 20 years or less	Age of site greater than 20 years	0.1287	0.429	1.278	0.144									
Environmental Performance	<div>Number of Sites in Each Gas Inspection Report Category by Landfill Age (20 Years or Less)</div> 	<div>Percent of Sites in Each Gas Inspection Report Category by Landfill Age (20 Years or Less)</div> 												
	Variable Type for Statistical Analysis	Dichotomous Independent Variable												
Results Statement	Whether or not a site is 20 years old or less does not increase or decrease the likelihood that it is in the category “Has Gas Inspection Report.”													

Site Characteristic (Independent Variable)	<div>Landfill Age (21–40 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site 21–40 years: 143</div> <div>Other: 81</div>																															
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Landfill age 21–40 years</td><td>Other</td><td>0.0378</td><td>1.795</td><td>3.119</td><td>1.033</td></tr></tbody></table> <div><div><div>Number of Sites in Each Gas Inspection Report Category by Landfill Age (21–40 Years)</div><table><thead><tr><th>Landfill Age</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>21–40 Years</td><td>64</td><td>79</td></tr><tr><td>Other</td><td>48</td><td>33</td></tr></tbody></table></div><div><div>Percent of Sites Within Each Gas Inspection Report Category by Landfill Age (21–40 Years)</div><table><thead><tr><th>Landfill Age</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>21–40 Years</td><td>71</td><td>57</td></tr><tr><td>Other</td><td>43</td><td>29</td></tr></tbody></table></div></div>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill age 21–40 years	Other	0.0378	1.795	3.119	1.033	Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report	21–40 Years	64	79	Other	48	33	Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	21–40 Years	71	57	Other	43	29
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																											
Landfill age 21–40 years	Other	0.0378	1.795	3.119	1.033																											
Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report																														
21–40 Years	64	79																														
Other	48	33																														
Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																														
21–40 Years	71	57																														
Other	43	29																														
Variable Type for Statistical Analysis	Dichotomous Independent Variable																															
Results Statement	A site between 21 and 40 years old is approximately 1.8 times less likely to be in the category “Has Gas Inspection Report” than are other sites.																															

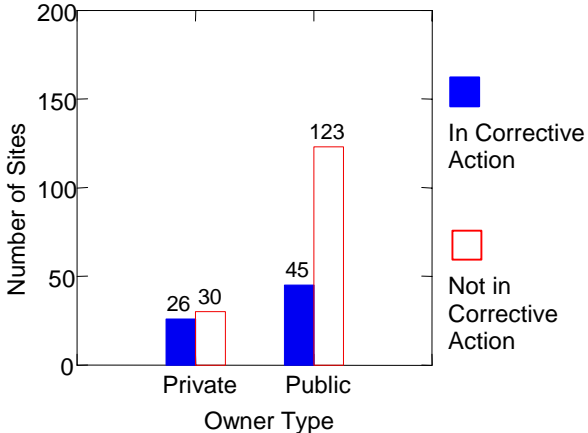
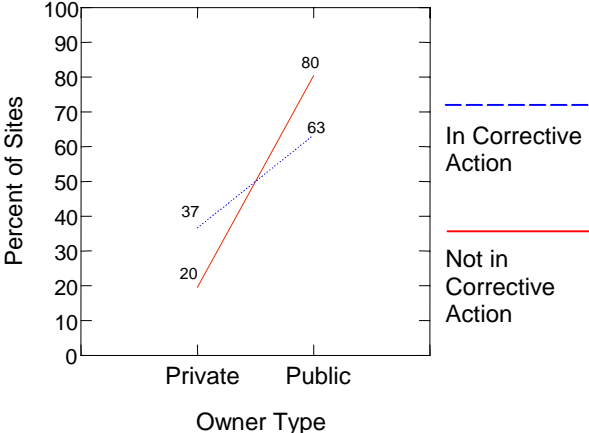
Site Characteristic (Independent Variable)	<div>Landfill Age (41–60 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site 41–60 years: 50</div> <div>Other: 174</div>																		
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Landfill age 41–60 years</td><td>Other</td><td>0.0561</td><td>1.873</td><td>3.567</td><td>0.984</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill age 41–60 years	Other	0.0561	1.873	3.567	0.984					
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio													
	Landfill age 41–60 years	Other	0.0561	1.873	3.567	0.984													
<div><div><div>Number of Sites in Each Gas Inspection Report Category by Landfill Age</div><table><tr><th>Landfill Age</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr><tr><td>41–60 Years</td><td>31</td><td>19</td></tr><tr><td>Other</td><td>81</td><td>93</td></tr></table></div><div><div>Percent of Sites Within Each Gas Inspection Report Category by Landfill Age</div><table><tr><th>Landfill Age</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr><tr><td>41–60 Years</td><td>28</td><td>17</td></tr><tr><td>Other</td><td>83</td><td>72</td></tr></table></div></div>		Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report	41–60 Years	31	19	Other	81	93	Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	41–60 Years	28	17	Other	83	72
Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report																	
41–60 Years	31	19																	
Other	81	93																	
Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																	
41–60 Years	28	17																	
Other	83	72																	
Variable Type for Statistical Analysis	Dichotomous Independent Variable																		
Results Statement	At a 95 percent significance level, whether a site is between 41 and 60 years old does not increase or decrease the likelihood of its being in the category “Has Gas Inspection Report.” Under a 90 percent significance level, results indicate that a site between 41 and 60 years old is approximately 1.9 times more likely to be in the category “Has Gas Inspection Report” than other sites.																		

Site Characteristic (Independent Variable)	<div>Landfill Age (Greater Than 60 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site greater than 60 years: 15</div> <div>Age of site less than or equal to 60 years: 209</div>																															
Environmental Performance	<div>Dependent Variable: Has Gas Inspection Report (Binary Values: “Has Gas Inspection Report” or “Does Not Have Gas Inspection Report”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Does Not Have Gas Inspection Report”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Landfill age greater than 60 years</td><td>Age of site less than or equal to 60 years</td><td>0.026</td><td>4.360</td><td>15.901</td><td>1.195</td></tr></tbody></table> <div><div><div>Number of Sites in Each Gas Inspection Report Category by Landfill Age (Greater Than 60 Years)</div><table><caption>Data for Number of Sites</caption><thead><tr><th>Landfill Age</th><th>Has Gas Inspection Report</th><th>Does Not Have Gas Inspection Report</th></tr></thead><tbody><tr><td>60 Years or Less</td><td>100</td><td>109</td></tr><tr><td>Over 60 Years</td><td>12</td><td>3</td></tr></tbody></table></div><div><div>Percent of Sites Within Each Gas Inspection Report Category by Landfill Age (Greater Than 60 years)</div><table><caption>Data for Percent of Sites</caption><thead><tr><th>Landfill Age</th><th>Has Gas Inspection Report (%)</th><th>Does Not Have Gas Inspection Report (%)</th></tr></thead><tbody><tr><td>60 Years or Less</td><td>89</td><td>97</td></tr><tr><td>Over 60 Years</td><td>3</td><td>11</td></tr></tbody></table></div></div>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Landfill age greater than 60 years	Age of site less than or equal to 60 years	0.026	4.360	15.901	1.195	Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report	60 Years or Less	100	109	Over 60 Years	12	3	Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)	60 Years or Less	89	97	Over 60 Years	3	11
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																											
Landfill age greater than 60 years	Age of site less than or equal to 60 years	0.026	4.360	15.901	1.195																											
Landfill Age	Has Gas Inspection Report	Does Not Have Gas Inspection Report																														
60 Years or Less	100	109																														
Over 60 Years	12	3																														
Landfill Age	Has Gas Inspection Report (%)	Does Not Have Gas Inspection Report (%)																														
60 Years or Less	89	97																														
Over 60 Years	3	11																														
Variable Type for Statistical Analysis	Dichotomous Independent Variable																															
Results Statement	A site that is over 60 years old is approximately 4.36 times more likely to be in the category “Has Gas Inspection Report” than other sites.																															

Appendix B-4

Assessment of Individual MSW Landfill Site Characteristics By Corrective Action Status

Results statements in this appendix are based on the study's Task 2 database inventory, which contains data on the 224 MSW landfills studied.

Site Characteristic (Independent Variable)	<div>Owner Type</div> <div>Value and Number of Landfills</div> <div>Public: 168</div> <div>Private: 56</div>																		
Environmental Performance	<div>Dependent Variable: “In Corrective Action” (Binary Values: “In Corrective Action” or “Not in Corrective Action”).</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Private</td><td>Public</td><td>0.007</td><td>2.369</td><td>4.432</td><td>1.266</td></tr></table>		Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Private	Public	0.007	2.369	4.432	1.266					
	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio													
	Private	Public	0.007	2.369	4.432	1.266													
<div>Number of Sites in Each Corrective Action Category by Owner Type</div> <div><table><thead><tr><th>Owner Type</th><th>In Corrective Action</th><th>Not in Corrective Action</th></tr></thead><tbody><tr><td>Private</td><td>26</td><td>30</td></tr><tr><td>Public</td><td>45</td><td>123</td></tr></tbody></table></div> <div>Percent of Sites in Each Corrective Action Category by Owner Type</div> <div><table><thead><tr><th>Owner Type</th><th>In Corrective Action (%)</th><th>Not in Corrective Action (%)</th></tr></thead><tbody><tr><td>Private</td><td>37</td><td>20</td></tr><tr><td>Public</td><td>63</td><td>80</td></tr></tbody></table></div>		Owner Type	In Corrective Action	Not in Corrective Action	Private	26	30	Public	45	123	Owner Type	In Corrective Action (%)	Not in Corrective Action (%)	Private	37	20	Public	63	80
Owner Type	In Corrective Action	Not in Corrective Action																	
Private	26	30																	
Public	45	123																	
Owner Type	In Corrective Action (%)	Not in Corrective Action (%)																	
Private	37	20																	
Public	63	80																	
Variable Type for Statistical Analysis	Categorical Independent Variable																		
Results Statement	Private sites are 2.37 times more likely to be in the category “In Corrective Action” than are public sites.																		

Site Characteristic (Independent Variable)	<div>Physical Setting</div> <div>Value and Number of Landfills</div> <div>Inland: 119 Desert: 58 Coastal: 17 Alpine: 13 High Desert: 9 Estuarine: 8</div>																																				
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “In Corrective Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>High Desert</td><td>Inland</td><td>0.117</td><td>5.408</td><td>44.649</td><td>0.655</td></tr><tr><td>Desert</td><td>Inland</td><td>0.001</td><td>3.681</td><td>8.188</td><td>1.655</td></tr><tr><td>Alpine</td><td>Inland</td><td>0.235</td><td>2.254</td><td>8.616</td><td>0.589</td></tr><tr><td>Coastal</td><td>Inland</td><td>0.599</td><td>0.761</td><td>2.11</td><td>0.274</td></tr><tr><td>Estuarine</td><td>Inland</td><td>0.399</td><td>2.028</td><td>10.473</td><td>0.393</td></tr></tbody></table> <div><div><div>Number of Sites in Each Corrective Action Category by Physical Setting</div></div><div><div>Percent of Sites in Each Corrective Action Category by Physical Setting</div></div></div>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	High Desert	Inland	0.117	5.408	44.649	0.655	Desert	Inland	0.001	3.681	8.188	1.655	Alpine	Inland	0.235	2.254	8.616	0.589	Coastal	Inland	0.599	0.761	2.11	0.274	Estuarine	Inland	0.399	2.028	10.473	0.393
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																																
High Desert	Inland	0.117	5.408	44.649	0.655																																
Desert	Inland	0.001	3.681	8.188	1.655																																
Alpine	Inland	0.235	2.254	8.616	0.589																																
Coastal	Inland	0.599	0.761	2.11	0.274																																
Estuarine	Inland	0.399	2.028	10.473	0.393																																
Variable Type for Statistical Analysis	Categorical Independent Variable																																				
Results Statement	Desert sites are 3.68 times less likely to be in the category “In Corrective Action” than inland sites. No other physical settings increase or decrease the likelihood of a site’s being in the category “In Corrective Action”.																																				

Site Characteristic (Independent Variable)	<div>Social Setting</div> <div>Value and Number of Landfills</div> <div>Rural: 139</div> <div>Urban: 71</div> <div>Suburban: 14</div>																								
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Urban</td><td>Inland</td><td>0.00002</td><td>3.791</td><td>7.002</td><td>2.053</td></tr><tr><td>Suburban</td><td>Inland</td><td>0.940</td><td>0.950</td><td>3.620</td><td>0.250</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Urban	Inland	0.00002	3.791	7.002	2.053	Suburban	Inland	0.940	0.950	3.620	0.250					
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																			
	Urban	Inland	0.00002	3.791	7.002	2.053																			
Suburban	Inland	0.940	0.950	3.620	0.250																				
<div>Number of Sites in Each Corrective Action Category by Social Setting</div> <table><thead><tr><th>Social Setting</th><th>In Corrective Action</th><th>Not in Corrective Action</th></tr></thead><tbody><tr><td>Rural</td><td>31</td><td>108</td></tr><tr><td>Suburban</td><td>3</td><td>11</td></tr><tr><td>Urban</td><td>37</td><td>34</td></tr></tbody></table> <div>Percent of Sites in Each Corrective Action Category by Social Setting</div> <table><thead><tr><th>Social Setting</th><th>In Corrective Action (%)</th><th>Not in Corrective Action (%)</th></tr></thead><tbody><tr><td>Rural</td><td>22</td><td>77</td></tr><tr><td>Suburban</td><td>2.3</td><td>97.7</td></tr><tr><td>Urban</td><td>52</td><td>48</td></tr></tbody></table>		Social Setting	In Corrective Action	Not in Corrective Action	Rural	31	108	Suburban	3	11	Urban	37	34	Social Setting	In Corrective Action (%)	Not in Corrective Action (%)	Rural	22	77	Suburban	2.3	97.7	Urban	52	48
Social Setting	In Corrective Action	Not in Corrective Action																							
Rural	31	108																							
Suburban	3	11																							
Urban	37	34																							
Social Setting	In Corrective Action (%)	Not in Corrective Action (%)																							
Rural	22	77																							
Suburban	2.3	97.7																							
Urban	52	48																							
Variable Type for Statistical Analysis	Categorical Independent Variable																								
Results Statement	Urban sites are 3.97 times more likely to be in the category “In Corrective Action” than rural sites. The suburban category does not increase or decrease the likelihood that a site is in the category “In Corrective Action.”																								

Site Characteristic (Independent Variable)	Minimum Depth to Underlying Groundwater Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1"> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> <tr> <td>Minimum Depth to Underlying Groundwater</td><td>0.136</td></tr> </table> <div> <div> <p>Log-Scale Frequency Diagram of Depth to Water by Corrective Action Status</p> </div> <div> <p>Box-and-Whisker Plot of Depth to Water by Corrective Action Status</p> </div> </div>	Independent Variable Category	Probability	Minimum Depth to Underlying Groundwater	0.136
Independent Variable Category	Probability				
Minimum Depth to Underlying Groundwater	0.136				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	There is no statistically significant difference in the depth to water between sites in the category “In Corrective Action” and those in the category “Not In Corrective Action.”				

Site Characteristic (Independent Variable)	<h2>Underlying Geologic Material</h2> <p>Value and Number of Landfills</p> <p>Sand and/or Gravel: 95 Silts/Clays: 62 Sedimentary Rock: 51 Igneous Rock: 16</p>																									
Environmental Performance	<p>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</p> <p>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “In Corrective Action”)</p> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>Sand and/or Gravel</td><td>0.36307</td><td>0.57143</td><td>1.90849</td><td>0.17109</td></tr><tr><td>Sedimentary Rock</td><td>Sand and/or Gravel</td><td>0.25349</td><td>0.64865</td><td>1.36356</td><td>0.30856</td></tr><tr><td>Silts/Clays</td><td>Sand and/or Gravel</td><td>0.3127</td><td>0.7013</td><td>1.39657</td><td>0.35216</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Igneous Rock	Sand and/or Gravel	0.36307	0.57143	1.90849	0.17109	Sedimentary Rock	Sand and/or Gravel	0.25349	0.64865	1.36356	0.30856	Silts/Clays	Sand and/or Gravel	0.3127	0.7013	1.39657	0.35216
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																				
	Igneous Rock	Sand and/or Gravel	0.36307	0.57143	1.90849	0.17109																				
Sedimentary Rock	Sand and/or Gravel	0.25349	0.64865	1.36356	0.30856																					
Silts/Clays	Sand and/or Gravel	0.3127	0.7013	1.39657	0.35216																					
	<p>Number of Sites in Each Corrective Action Category by Underlying Geologic Material</p>	<p>Percent of Sites in Each Corrective Action Category by Underlying Geologic Material</p>																								
Variable Type for Statistical Analysis	Categorical Independent Variable																									
Results Statement	Underlying geologic material does not increase or decrease the likelihood that a site is in the category “In Corrective Action”.																									

Site Characteristic (Independent Variable)	Average Annual Precipitation Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1"> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> <tr> <td>Average Annual Precipitation</td><td>0.033</td></tr> </table> <div> <div> <p>Log-Scale Frequency Diagram of Average Annual Precipitation by Corrective Action Status</p> </div> <div> <p>Box-and-Whisker Plot of Average Annual Precipitation by Corrective Action Status</p> </div> </div>	Independent Variable Category	Probability	Average Annual Precipitation	0.033
Independent Variable Category	Probability				
Average Annual Precipitation	0.033				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	The average annual precipitation is statistically different (in this case greater) for sites in the category “In Corrective Action” than for sites in the category “Not In Corrective Action.”				

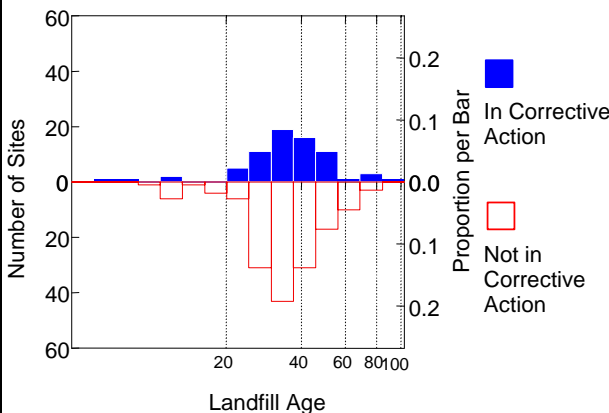
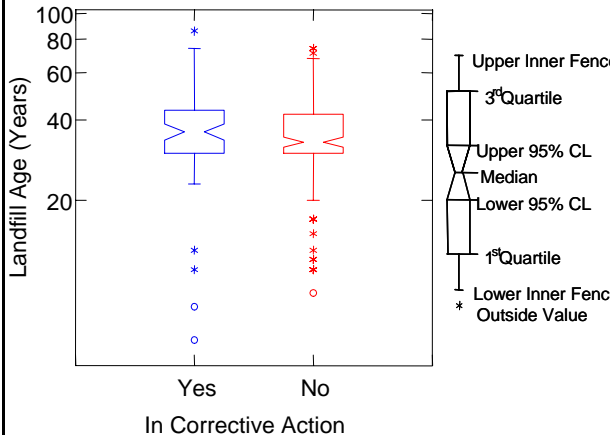
Site Characteristic (Independent Variable)	<div>Landfill Gas Collection System</div> <div>Value and Number of Landfills</div> <div>Yes: 103</div> <div>No: 121</div>												
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Not in Corrective Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Yes (have landfill gas monitoring)</td><td>No (do not have landfill gas monitoring)</td><td>0.0000</td><td>5.474</td><td>10.213</td><td>2.934</td></tr></table> <div><div><div>Number of Sites in Each Corrective Monitoring Category by Landfill Gas Collection System</div></div><div><div>Percent of Sites in Each Category by Landfill Gas Collection System</div></div></div>	Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Yes (have landfill gas monitoring)	No (do not have landfill gas monitoring)	0.0000	5.474	10.213	2.934
Independent Variable Category	Reference Value	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
Yes (have landfill gas monitoring)	No (do not have landfill gas monitoring)	0.0000	5.474	10.213	2.934								
Variable Type for Statistical Analysis	Dichotomous Independent Variable												
Results Statement	Sites that have landfill gas collection systems are 5.47 times more likely to be in the category “In Corrective Action” than those that do not have landfill gas collection systems.												

Site Characteristic (Independent Variable)	Landfill Size (Permitted Disposal Area) Value and Number of Landfills Continuous				
Environmental Performance	<p>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</p> <p style="text-align: center;">Summary Table of Results (Kruskal-Wallis Analysis of Variance)</p> <table border="1"> <thead> <tr> <th>Independent Variable Category</th><th>Probability</th></tr> </thead> <tbody> <tr> <td>Permitted Disposal Area</td><td>0.007</td></tr> </tbody> </table> <div> <div> <p>Log-Scale Frequency Diagram of Permitted Disposal Area by Corrective Action Status</p> </div> <div> <p>Box-and-Whisker Plot of Permitted Disposal Area by Corrective Action Status</p> </div> </div>	Independent Variable Category	Probability	Permitted Disposal Area	0.007
Independent Variable Category	Probability				
Permitted Disposal Area	0.007				
Variable Type for Statistical Analysis	Continuous Independent Variable				
Results Statement	The permitted landfill area is statistically different (in this case greater) for sites in the category “In Corrective Action” than for sites in the category “Not In Corrective Action.”				

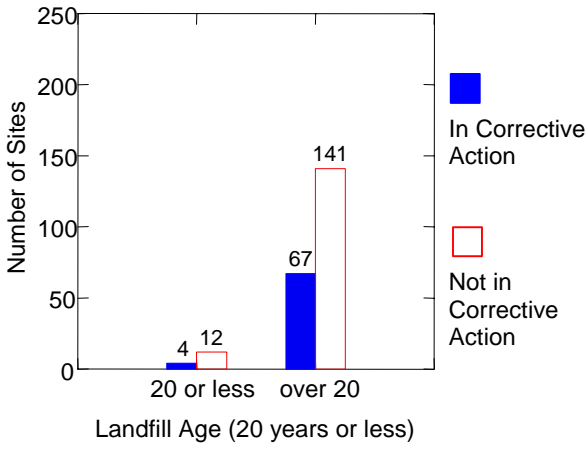
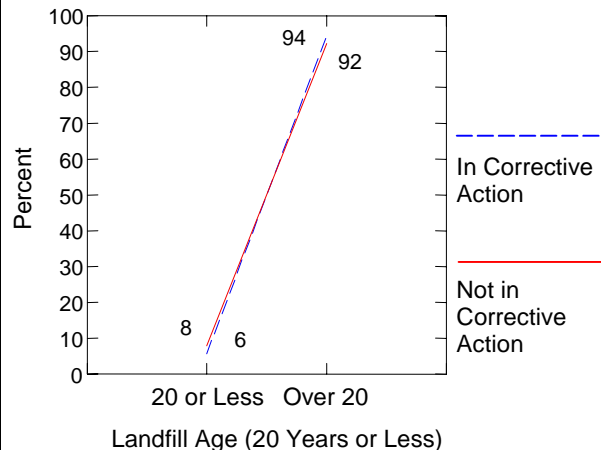
Site Characteristic (Independent Variable)	Liner Type (Whole Site) Value and Number of Landfills Completely Subtitle* D or Subtitle D Alternative: 4 Fully Lined – Partially Non-Subtitle D or Non-Subtitle D Alternative: 12 Partially Unlined: 70 Fully Unlined: 138 *Also referred to as “Sub-D.”																								
Environmental Performance	Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”) <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Not in Corrective Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Sub-D or Sub-D alternative</td><td>Fully Unlined</td><td>0.840</td><td>0.795</td><td>7.368</td><td>0.086</td></tr><tr><td>Fully lined – partially non-Sub-D or non-Sub-D alternative</td><td>Fully Unlined</td><td>0.184</td><td>2.273</td><td>7.640</td><td>0.676</td></tr><tr><td>Partially Unlined</td><td>Fully Unlined</td><td>0.001</td><td>2.752</td><td>5.084</td><td>1.489</td></tr></table>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Sub-D or Sub-D alternative	Fully Unlined	0.840	0.795	7.368	0.086	Fully lined – partially non-Sub-D or non-Sub-D alternative	Fully Unlined	0.184	2.273	7.640	0.676	Partially Unlined	Fully Unlined	0.001	2.752	5.084	1.489
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																				
Completely Sub-D or Sub-D alternative	Fully Unlined	0.840	0.795	7.368	0.086																				
Fully lined – partially non-Sub-D or non-Sub-D alternative	Fully Unlined	0.184	2.273	7.640	0.676																				
Partially Unlined	Fully Unlined	0.001	2.752	5.084	1.489																				

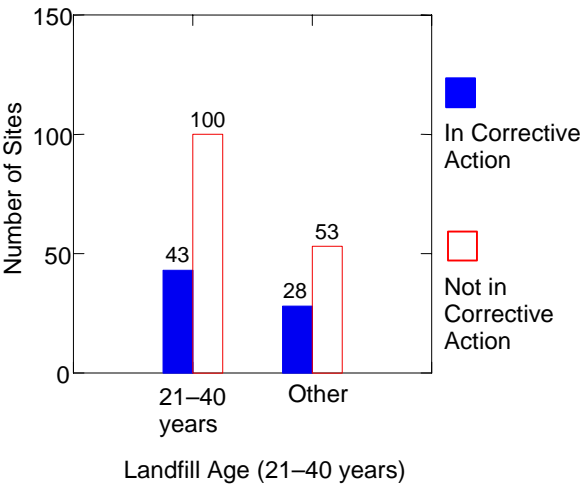
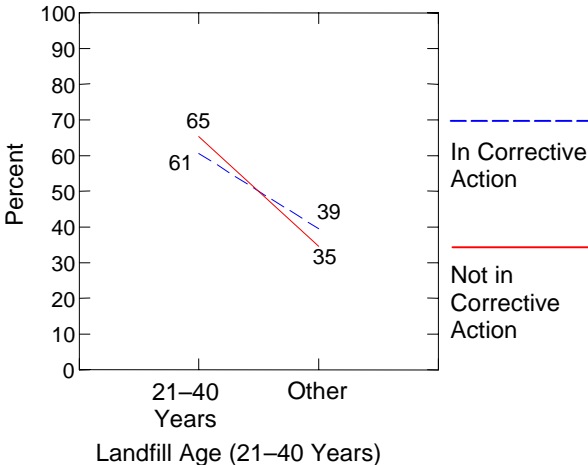
	<div> <div> <p>Number of Sites in Each Corrective Action Category by Liner Type</p> <table border="1"> <thead> <tr> <th>Liner Type</th> <th>In Corrective Action</th> <th>Not in Corrective Action</th> </tr> </thead> <tbody> <tr> <td>Fully Lined Sub-D or Alternative</td> <td>1</td> <td>3</td> </tr> <tr> <td>Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative</td> <td>5</td> <td>7</td> </tr> <tr> <td>Fully Unlined</td> <td>33</td> <td>105</td> </tr> <tr> <td>Partially Unlined</td> <td>32</td> <td>38</td> </tr> </tbody> </table> </div> <div> <p>Percent of Sites in Each Corrective Action Category by Liner Type</p> <table border="1"> <thead> <tr> <th>Liner Type</th> <th>In Corrective Action (%)</th> <th>Not in Corrective Action (%)</th> </tr> </thead> <tbody> <tr> <td>Fully Lined Sub-D or Alt</td> <td>1</td> <td>3</td> </tr> <tr> <td>Fully Lined-Partially Non-Sub-D or Alt</td> <td>7</td> <td>5</td> </tr> <tr> <td>Fully Unlined</td> <td>46</td> <td>69</td> </tr> <tr> <td>Partially Unlined</td> <td>45</td> <td>24</td> </tr> </tbody> </table> </div> </div>	Liner Type	In Corrective Action	Not in Corrective Action	Fully Lined Sub-D or Alternative	1	3	Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative	5	7	Fully Unlined	33	105	Partially Unlined	32	38	Liner Type	In Corrective Action (%)	Not in Corrective Action (%)	Fully Lined Sub-D or Alt	1	3	Fully Lined-Partially Non-Sub-D or Alt	7	5	Fully Unlined	46	69	Partially Unlined	45	24	
Liner Type	In Corrective Action	Not in Corrective Action																														
Fully Lined Sub-D or Alternative	1	3																														
Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative	5	7																														
Fully Unlined	33	105																														
Partially Unlined	32	38																														
Liner Type	In Corrective Action (%)	Not in Corrective Action (%)																														
Fully Lined Sub-D or Alt	1	3																														
Fully Lined-Partially Non-Sub-D or Alt	7	5																														
Fully Unlined	46	69																														
Partially Unlined	45	24																														
Variable Type for Statistical Analysis	Categorical Independent Variable																															
Results Statement	Partially unlined sites are 2.75 times more likely to be in the category “In Corrective Action” than fully unlined sites. No other liner category increases or decreases the likelihood that a site is in the category “In Corrective Action” relative to fully unlined sites.																															

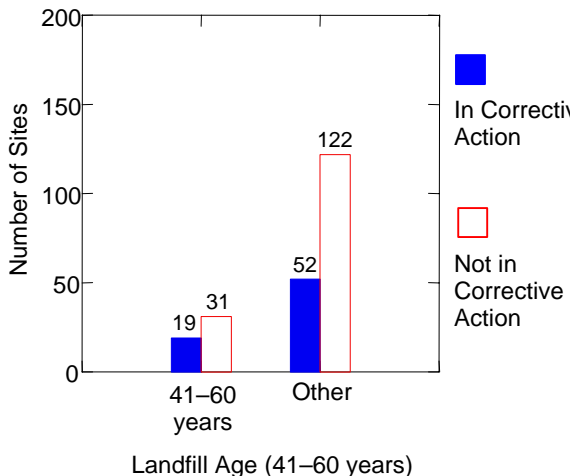
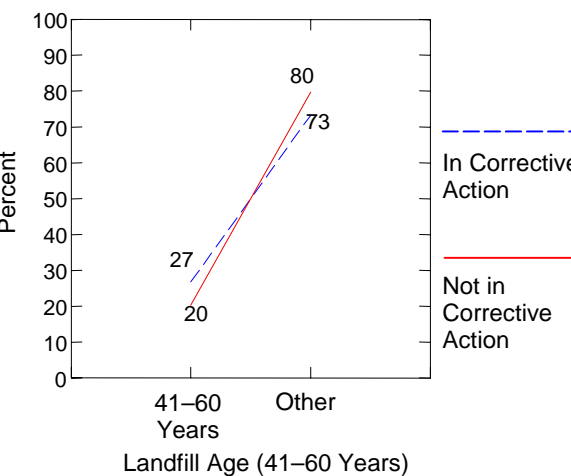
Site Characteristic (Independent Variable)	<div>Cover Type (Whole Site)</div> <div>Value and Number of Landfills</div> <div>Completely Covered: 48 Partially Uncovered: 30 Completely Uncovered: 146</div>																		
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div><div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Not in Corrective Action”)</div><table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Completely Covered</td><td>Fully Uncovered</td><td>0.182</td><td>1.585</td><td>3.11</td><td>0.807</td></tr><tr><td>Partially Uncovered</td><td>Fully Uncovered</td><td>0.184</td><td>1.777</td><td>4.151</td><td>0.761</td></tr></table></div> <div><div><div>Number of Sites in Each Corrective Action Category by Cover Type</div></div><div><div>Percent of Sites in Each Corrective Action Category by Cover Type</div></div></div>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Completely Covered	Fully Uncovered	0.182	1.585	3.11	0.807	Partially Uncovered	Fully Uncovered	0.184	1.777	4.151	0.761
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio													
	Completely Covered	Fully Uncovered	0.182	1.585	3.11	0.807													
Partially Uncovered	Fully Uncovered	0.184	1.777	4.151	0.761														
Variable Type for Statistical Analysis	Categorical Independent Variable																		
Results Statement	Cover type does not increase or decrease the likelihood that a site is in the category “In Corrective Action.”																		

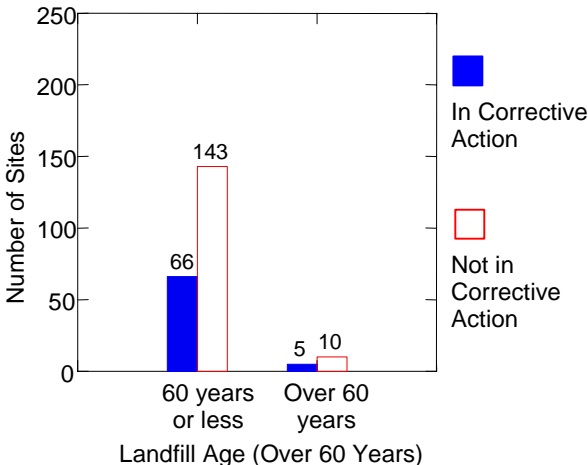
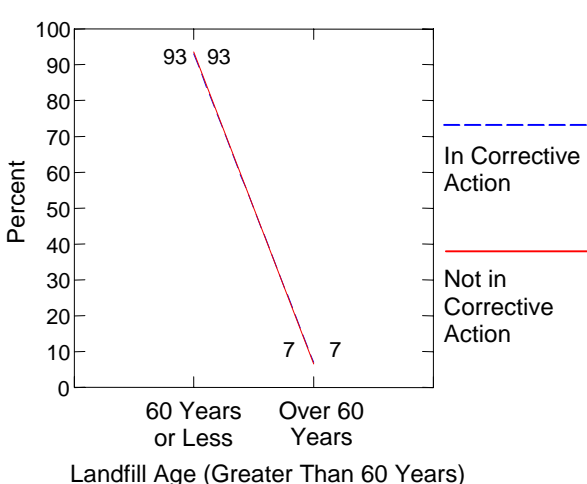
Site Characteristic (Independent Variable)	<div>Landfill Age</div> <div>Value and Number of Landfills</div> <div>Continuous</div>					
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div><div>Summary Table of Results</div><div>(Kruskal-Wallis Analysis of Variance)</div><table><tr><th>Independent Variable Category</th><th>Probability</th></tr><tr><td>Age of Site</td><td>0.253</td></tr></table></div>		Independent Variable Category	Probability	Age of Site	0.253
	Independent Variable Category	Probability				
	Age of Site	0.253				
<div><div>Log-Scale Frequency Diagram of Landfill Age by Corrective Action Status</div></div> <div><div>Box-and-Whisker Plot of Landfill Age by Monitoring Status</div></div>						
Variable Type for Statistical Analysis	Continuous Independent Variable					
Results Statement	There is no statistically significant difference between the ages of sites in the category “In Corrective Action” and those in the category “Not In Corrective Action.”					

Site Characteristic (Independent Variable)	<div>Landfill Age (Construction Before/During 1984 or After 1984)</div> <div>Value and Number of Landfills</div> <div>Construction date before/during 1984: 209</div> <div>Construction after 1984: 15</div>													
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Construction date after 1984</td><td>Construction date before/during 1984</td><td>0.666</td><td>0.771</td><td>2.510</td><td>0.237</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Construction date after 1984	Construction date before/during 1984	0.666	0.771	2.510	0.237
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Construction date after 1984	Construction date before/during 1984	0.666	0.771	2.510	0.237								
<div><div><div>Number of Sites in Each Corrective Action Category by Landfill Age (Construction Before/During or After 1984)</div></div><div><div>Percent of Sites Within Each Corrective Action Category by Landfill Age (Construction Before/During or After 1984)</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether a site was built before/during 1984 or after 1984 does not increase or decrease the likelihood that it is in the category “In Corrective Action.”													

Site Characteristic (Independent Variable)	<div>Landfill Age (20 Years or Less)</div> <div>Value and Number of Landfills</div> <div>Age of site 20 years or less: 16</div> <div>Age of site greater than 20 years: 208</div>																														
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Age of site 20 years or less</td><td>Age of site greater than 20 years</td><td>0.552</td><td>0.701</td><td>2.257</td><td>0.218</td></tr></tbody></table> <div><div><div>Number of Sites in Each Corrective Action Category by Landfill Age (20 Years or Less)</div><table><caption>Data for Number of Sites in Each Corrective Action Category</caption><thead><tr><th>Landfill Age (20 years or less)</th><th>In Corrective Action</th><th>Not in Corrective Action</th></tr></thead><tbody><tr><td>20 or less</td><td>4</td><td>12</td></tr><tr><td>over 20</td><td>67</td><td>141</td></tr></tbody></table></div><div><div>Percent of Sites in Each Corrective Action Category by Landfill Age (20 years or less)</div><table><caption>Data for Percent of Sites in Each Corrective Action Category</caption><thead><tr><th>Landfill Age (20 Years or Less)</th><th>In Corrective Action (%)</th><th>Not in Corrective Action (%)</th></tr></thead><tbody><tr><td>20 or Less</td><td>8</td><td>94</td></tr><tr><td>Over 20</td><td>6</td><td>92</td></tr></tbody></table></div></div>	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Age of site 20 years or less	Age of site greater than 20 years	0.552	0.701	2.257	0.218	Landfill Age (20 years or less)	In Corrective Action	Not in Corrective Action	20 or less	4	12	over 20	67	141	Landfill Age (20 Years or Less)	In Corrective Action (%)	Not in Corrective Action (%)	20 or Less	8	94	Over 20	6	92
Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio																										
Age of site 20 years or less	Age of site greater than 20 years	0.552	0.701	2.257	0.218																										
Landfill Age (20 years or less)	In Corrective Action	Not in Corrective Action																													
20 or less	4	12																													
over 20	67	141																													
Landfill Age (20 Years or Less)	In Corrective Action (%)	Not in Corrective Action (%)																													
20 or Less	8	94																													
Over 20	6	92																													
Variable Type for Statistical Analysis	Dichotomous Independent Variable																														
Results Statement	Whether or not a site is 20 years old or less does not increase or decrease the likelihood of its being in the category “In Corrective Action.”																														

Site Characteristic (Independent Variable)	<div>Landfill Age (21–40 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site 21–40 years: 143</div> <div>Other: 81</div>													
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Age of site 21–40 years</td><td>Other</td><td>0.4873</td><td>0.814</td><td>1.455</td><td>0.455</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Age of site 21–40 years	Other	0.4873	0.814	1.455	0.455
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Age of site 21–40 years	Other	0.4873	0.814	1.455	0.455								
<div><div><div>Number of Sites in Each Corrective Action Category by Landfill Age (21–40 Years)</div></div><div><div>Percent of Sites in Each Corrective Action Category by Landfill Age (21–40 Years)</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether or not a site is 21–0 years old does not increase or decrease the likelihood of its being in the category “In Corrective Action.”													

Site Characteristic (Independent Variable)	<div>Landfill Age (41–60 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site 41–60–years: 50 Other: 174</div>													
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression (Reference Dependent Variable: “Not in Corrective Action”)</div> <table><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds-Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr><tr><td>Age of site 41–60 years</td><td>Other</td><td>0.278</td><td>1.438</td><td>2.773</td><td>0.746</td></tr></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Age of site 41–60 years	Other	0.278	1.438	2.773	0.746
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds-Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
	Age of site 41–60 years	Other	0.278	1.438	2.773	0.746								
<div><div><div>Number of Sites in Each Corrective Action Category by Landfill Age (41–60 Years)</div></div><div><div>Percent of Sites in Each Monitoring Status Category Landfill Age (41–60 Years)</div></div></div>														
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether a site is between 41 and 60 years old does not increase or decrease the likelihood that it is “In Corrective Action.”													

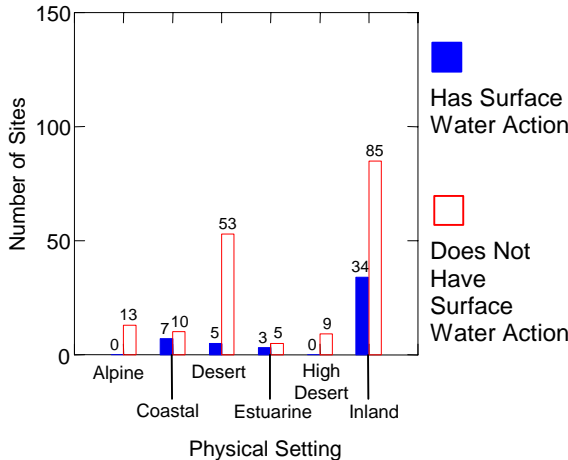
Site Characteristic (Independent Variable)	<div>Landfill Age (Greater Than 60 Years)</div> <div>Value and Number of Landfills</div> <div>Age of site greater than 60 years: 15</div> <div>Age of site less than or equal to 60 years: 209</div>													
Environmental Performance	<div>Dependent Variable: In Corrective Action (Binary Values: “In Corrective Action” or “Not in Corrective Action”)</div> <div>Summary Table of Results – Logistic Regression</div> <div>(Reference Dependent Variable: “Not in Corrective Action”)</div> <table><thead><tr><th>Independent Variable Category</th><th>Reference Value for Independent Variable</th><th>Probability</th><th>Odds Ratio</th><th>Upper 95% Bound on Odds Ratio</th><th>Lower 95% Bound on Odds Ratio</th></tr></thead><tbody><tr><td>Age of site greater than 60 years</td><td>Age of site less than/equal to 60 years</td><td>0.8879</td><td>1.083</td><td>3.295</td><td>0.356</td></tr></tbody></table>		Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio	Age of site greater than 60 years	Age of site less than/equal to 60 years	0.8879	1.083	3.295	0.356
	Independent Variable Category	Reference Value for Independent Variable	Probability	Odds Ratio	Upper 95% Bound on Odds Ratio	Lower 95% Bound on Odds Ratio								
Age of site greater than 60 years	Age of site less than/equal to 60 years	0.8879	1.083	3.295	0.356									
	<div>Number of Sites in Each Corrective Action Category by Landfill Age (Greater Than 60 Years)</div> 	<div>Percent of Sites Within Each Monitoring Status Category by Landfill (Greater Than 60 Years)</div> 												
Variable Type for Statistical Analysis	Dichotomous Independent Variable													
Results Statement	Whether or not a site is over 60 years old does not increase or decrease the likelihood of its being in the category “In Corrective Action.”													

Appendix B-5

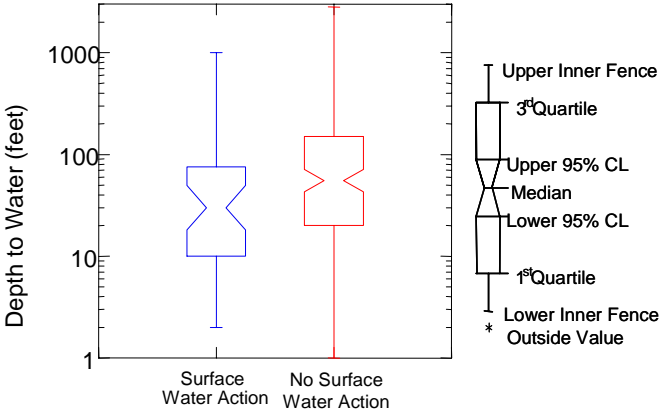
Assessment of Individual MSW Landfill Site Characteristics by Surface Water Action

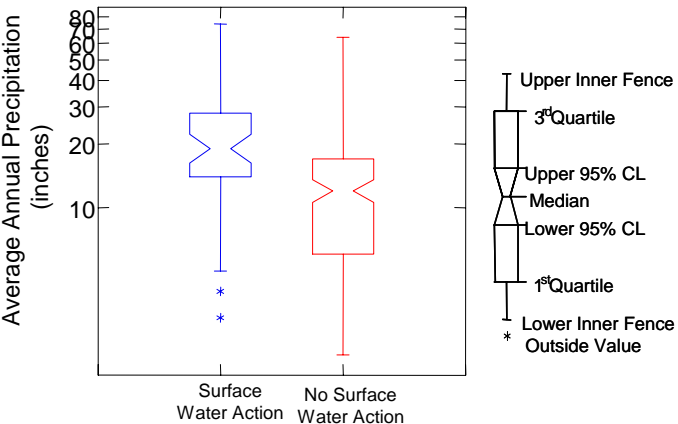
Summary of significant results from analysis of correlation between landfill site characteristics and surface water performance. See Section 4.1.5 for discussion.

Results statements in this appendix are based on the study's Task 2 database inventory, which contains data on the 224 MSW landfills studied.

Site Characteristic (Independent Variable)	<div>Physical Setting</div> <div>Value and Number of Landfills</div> <div>Inland: 119 Desert: 58 Coastal: 17 Alpine: 13 High Desert: 9 Estuarine: 8</div>																				
Environmental Performance	Dependent Variable: Has Surface Water Action (Binary Values: “Has Surface Water Action” or “Does Not Have Surface Water Action”)																				
	<div>Number of Sites in Each Surface Water Action Category by Physical Setting</div> <div><table><thead><tr><th>Physical Setting</th><th>Has Surface Water Action</th><th>Does Not Have Surface Water Action</th></tr></thead><tbody><tr><td>Alpine</td><td>0</td><td>13</td></tr><tr><td>Coastal</td><td>7</td><td>10</td></tr><tr><td>Desert</td><td>5</td><td>53</td></tr><tr><td>Estuarine</td><td>3</td><td>5</td></tr><tr><td>High Desert</td><td>0</td><td>9</td></tr><tr><td>Inland</td><td>34</td><td>85</td></tr></tbody></table></div>	Physical Setting	Has Surface Water Action	Does Not Have Surface Water Action	Alpine	0	13	Coastal	7	10	Desert	5	53	Estuarine	3	5	High Desert	0	9	Inland	34
Physical Setting	Has Surface Water Action	Does Not Have Surface Water Action																			
Alpine	0	13																			
Coastal	7	10																			
Desert	5	53																			
Estuarine	3	5																			
High Desert	0	9																			
Inland	34	85																			
Variable Type for Statistical Analysis	Categorical Independent Variable																				
Results Statement	It is approximately 4.2 times less likely that a desert site is in the category “Has Surface Water Action” than an inland site.																				

Site Characteristic (Independent Variable)	<div>Underlying Geologic Material</div> <div>Value and Number of Landfills</div> <div>Sand and/or Gravel: 95 Silts/Clays: 62 Sedimentary Rock: 51 Igneous Rock: 16</div>														
Environmental Performance	Dependent Variable: Has Surface Water Action (Binary Values: “Has Surface Water Action” or “Does Not Have Surface Water Action”)														
	<div>Number of Sites in Each Surface Water Action Category by Underlying Geologic Material</div> <div><table><thead><tr><th>Underlying Geologic Material</th><th>Has Surface Water Action</th><th>Does Not Have Surface Water Action</th></tr></thead><tbody><tr><td>Igneous Rock</td><td>2</td><td>14</td></tr><tr><td>Sand and/or Gravel</td><td>13</td><td>82</td></tr><tr><td>Sedimentary Rock</td><td>14</td><td>37</td></tr><tr><td>Silts/Clays</td><td>20</td><td>42</td></tr></tbody></table></div>	Underlying Geologic Material	Has Surface Water Action	Does Not Have Surface Water Action	Igneous Rock	2	14	Sand and/or Gravel	13	82	Sedimentary Rock	14	37	Silts/Clays	20
Underlying Geologic Material	Has Surface Water Action	Does Not Have Surface Water Action													
Igneous Rock	2	14													
Sand and/or Gravel	13	82													
Sedimentary Rock	14	37													
Silts/Clays	20	42													
Variable Type for Statistical Analysis	Categorical Independent Variable														
Results Statement	It is approximately 2.4 times more likely that a sedimentary rock site is in the category “Has Surface Water Action” than a sand and/or gravel site, and it is approximately 3 times more likely that a silts/clays site is in the category “Has Surface Water Action” than a sand and/or gravel site.														

Site Characteristic (Independent Variable)	Minimum Depth to Underlying Groundwater Value and Number of Landfills Continuous
Environmental Performance	Dependent Variable: Has Surface Water Action (Binary Values: “Has Surface Water Action” or “Does Not Have Surface Water Action”)
	Box and Whisker Plot of Surface Water Action Category by Minimum Depth to Underlying Groundwater 
Variable Type for Statistical Analysis	Continuous Independent Variable
Results Statement	Minimum depth to underlying groundwater is statistically different (in this case, less) for sites in the category “Has Surface Water Action.”

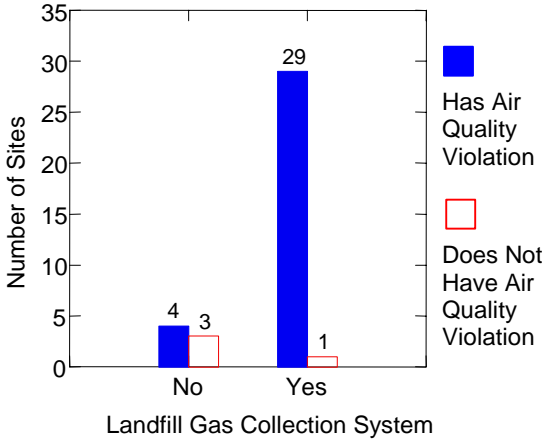
Site Characteristic (Independent Variable)	Average Annual Precipitation Value and Number of Landfills Continuous
Environmental Performance	Dependent Variable: Has Surface Water Action (Binary Values: “Has Surface Water Action” or “Does Not Have Surface Water Action”)
	Box and Whisker Plot of Surface Water Action Category by Average Annual Precipitation 
Variable Type for Statistical Analysis	Continuous Independent Variable
Results Statement	The average annual precipitation is statistically different (in this case, greater) for sites in the category “Has Surface Water Action.”

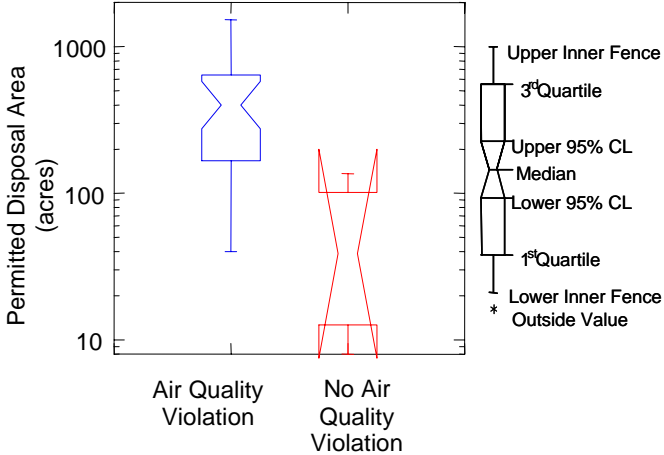
Appendix B-6:

Assessment of Individual MSW Landfill Site Characteristics By Air Quality Violation

Summary of significant results from analysis of correlation between landfill site characteristics and air quality performance for South Coast Air Quality Management District (SCAQMD) and Bay Area Air Quality Management District (BAAQMD). See Sections 4.11.2 and 4.3.2 for discussion.

Results statements in this appendix are based on the study's Task 2 database inventory, which contains data on the 224 MSW landfills studied.

Site Characteristic (Independent Variable)	<div>Landfill Gas Collection System</div> <div>Value and Number of Landfills</div> <div>Yes: 30</div> <div>No: 7</div>								
Environmental Performance	Dependent Variable: Has Air Quality Violation (Binary Values: “Has Air Quality Violation” or “Does Not Have Air Quality Violation”)								
	<div>Number of Sites in Each Air Quality Violation Category by Landfill Gas Collection System</div> <div><table><thead><tr><th>Landfill Gas Collection System</th><th>Has Air Quality Violation</th><th>Does Not Have Air Quality Violation</th></tr></thead><tbody><tr><td>No</td><td>4</td><td>3</td></tr><tr><td>Yes</td><td>29</td><td>1</td></tr></tbody></table></div>	Landfill Gas Collection System	Has Air Quality Violation	Does Not Have Air Quality Violation	No	4	3	Yes	29
Landfill Gas Collection System	Has Air Quality Violation	Does Not Have Air Quality Violation							
No	4	3							
Yes	29	1							
Variable Type for Statistical Analysis	Dichotomous Independent Variable								
Results Statement	It is approximately 22.1 times more likely that sites with landfill gas collection systems are in the category “Has Air Quality Violation” than those that do not have landfill gas collection systems.								

Site Characteristic (Independent Variable)	Landfill Size (Permitted Disposal Area) Value and Number of Landfills Continuous
Environmental Performance	Dependent Variable: Has Air Quality Violation (Binary Values: “Has Air Quality Violation” or “Does Not Have Air Quality Violation”)
	Box and Whisker Plot of Air Quality Violation Category by Permitted Disposal Area 
Variable Type for Statistical Analysis	Continuous Independent Variable
Results Statement	Permitted disposal area is statistically different (in this case, greater) for SCAQMD/BAAQMD sites in the category “Has Air Quality Violation.”

Appendix C-1

Analysis of Independence—Owner Type

Statistical analysis of data in the inventory shows that private sites are 2.37 times more likely to be in corrective action than public sites.

The correlation between *Owner Type* and “In Corrective Action” implies causation (with *Owner Type* influencing or resulting in whether the site is in corrective action). However, to better understand if the variable *Owner Type* is independent in its correlation with corrective action, the information was further analyzed.

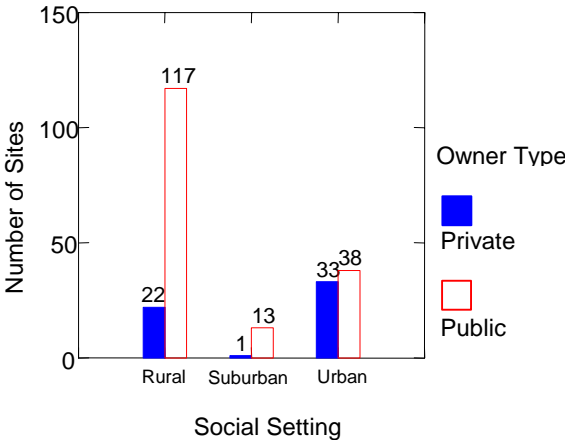
As discussed in Section 3.2.3, it appears that a handful of the landfill site characteristics designated as independent variables are, in fact, related to (and therefore dependent on) one or more other site variables. This potential correlation to other independent variables was examined for the variable *Owner Type* using logistic regression analysis. Complete results and graphical summary of this analysis are provided below.

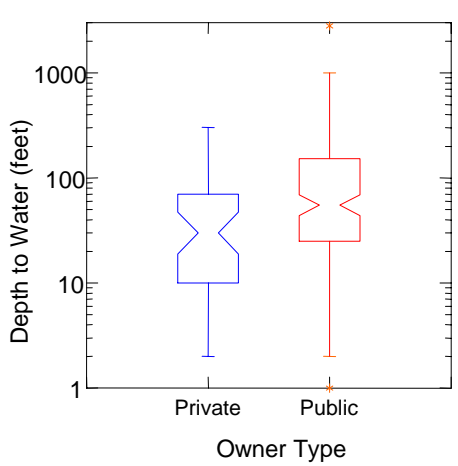
The following statements are based on qualification and analysis of these results:

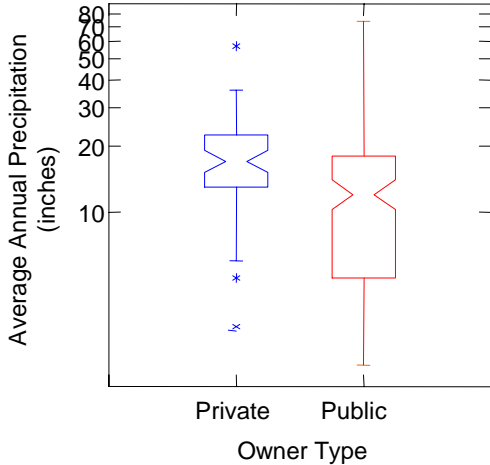
1. There appears to be some relationship between the estuarine physical setting and private ownership. However, this is not relevant to the single-factor analyses, since no significant correlation was found between the estuarine physical setting and any of the environmental factors.
2. The correlation between private ownership and the status “In Corrective Action” noted in Section 4.1.2 may to varying degrees be due to the relationship between *Owner Type* and one or more of the following site characteristics: *Social Setting*, *Landfill Gas Collection System*, *Liner Type*, *Landfill Size (Permitted Disposal Area)* and *Average Annual Precipitation*. The latter five variables also exhibited a positive correlation with the status “In Corrective Action” and with *Owner Type*.

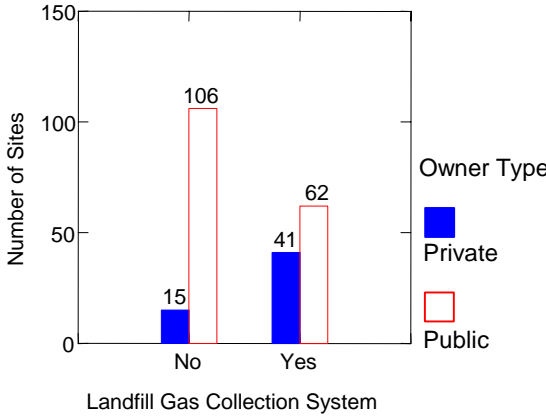
The analysis of the variable *Owner Type* indicates that, based on the available data, the following independent variables are correlated to whether a site is private or public:

Site Characteristic (Independent Variable)	<h3>Physical Setting</h3> <p>Value and Number of Landfills</p> <p>Inland: 119 Desert: 58 Coastal: 17 Alpine: 13 High Desert: 9 Estuarine: 8</p>																				
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)																				
	<p>Number of Sites in Each Owner Type Category by Physical Setting</p> <table><thead><tr><th>Physical Setting</th><th>Private</th><th>Public</th></tr></thead><tbody><tr><td>Alpine</td><td>3</td><td>10</td></tr><tr><td>Coastal</td><td>4</td><td>13</td></tr><tr><td>Desert</td><td>6</td><td>52</td></tr><tr><td>Estuarine</td><td>6</td><td>2</td></tr><tr><td>High Desert</td><td>0</td><td>9</td></tr><tr><td>Inland</td><td>37</td><td>82</td></tr></tbody></table>	Physical Setting	Private	Public	Alpine	3	10	Coastal	4	13	Desert	6	52	Estuarine	6	2	High Desert	0	9	Inland	37
Physical Setting	Private	Public																			
Alpine	3	10																			
Coastal	4	13																			
Desert	6	52																			
Estuarine	6	2																			
High Desert	0	9																			
Inland	37	82																			
Variable Type for Statistical Analysis	Categorical Independent Variable																				
Results Statement	Desert sites are approximately 3.9 times less likely to be privately owned than inland sites, and estuarine sites are approximately 6.6 times more likely to be privately owned than inland sites.																				

Site Characteristic (Independent Variable)	<div>Social Setting</div> <div>Value and Number of Landfills</div> <div>Rural: 139 Urban: 71 Suburban: 14</div>											
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)											
	<div>Number of Sites in Each Owner Type Category by Social Setting</div> <div><table><thead><tr><th>Social Setting</th><th>Private</th><th>Public</th></tr></thead><tbody><tr><td>Rural</td><td>22</td><td>117</td></tr><tr><td>Suburban</td><td>1</td><td>13</td></tr><tr><td>Urban</td><td>33</td><td>38</td></tr></tbody></table></div>	Social Setting	Private	Public	Rural	22	117	Suburban	1	13	Urban	33
Social Setting	Private	Public										
Rural	22	117										
Suburban	1	13										
Urban	33	38										
Variable Type for Statistical Analysis	Categorical Independent Variable											
Results Statement	Urban sites are approximately 4.6 times more likely to be privately owned than rural sites.											

Site Characteristic (Independent Variable)	Minimum Depth to Underlying Groundwater Value and Number of Landfills Continuous																				
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)																				
	Box and Whisker Plot of Owner Type Category by Minimum Depth to Underlying Groundwater  <table><caption>Approximate data from Box and Whisker Plot</caption><thead><tr><th>Owner Type</th><th>Min (Whisker)</th><th>Q1</th><th>Median</th><th>Q3</th><th>Max (Whisker)</th><th>Outliers</th></tr></thead><tbody><tr><td>Private</td><td>3</td><td>10</td><td>20</td><td>80</td><td>300</td><td>1000</td></tr><tr><td>Public</td><td>2</td><td>20</td><td>30</td><td>150</td><td>1000</td><td>1000</td></tr></tbody></table>	Owner Type	Min (Whisker)	Q1	Median	Q3	Max (Whisker)	Outliers	Private	3	10	20	80	300	1000	Public	2	20	30	150	1000
Owner Type	Min (Whisker)	Q1	Median	Q3	Max (Whisker)	Outliers															
Private	3	10	20	80	300	1000															
Public	2	20	30	150	1000	1000															
Variable Type for Statistical Analysis	Continuous Independent Variable																				
Results Statement	Depth to water is statistically different (in this case, less) for private sites.																				

Site Characteristic (Independent Variable)	<div>Average Annual Precipitation</div> <div>Value and Number of Landfills</div> <div>Continuous</div>
Analysis of Independence	<div>Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)</div> <div>Box and Whisker Plot of Owner Type Category by Average Annual Precipitation</div> <div></div>
Variable Type for Statistical Analysis	Continuous Independent variable
Results Statement	The average annual precipitation is statistically different (in this case, greater) for private sites.

Site Characteristic (Independent Variable)	Landfill Gas Collection System Value and Number of Landfills Yes: 103 No: 121								
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)								
	Number of Sites in Each Owner Type Category by Landfill Gas Collection System  <table><thead><tr><th>Landfill Gas Collection System</th><th>Private</th><th>Public</th></tr></thead><tbody><tr><td>No</td><td>15</td><td>106</td></tr><tr><td>Yes</td><td>41</td><td>62</td></tr></tbody></table>	Landfill Gas Collection System	Private	Public	No	15	106	Yes	41
Landfill Gas Collection System	Private	Public							
No	15	106							
Yes	41	62							
Variable Type for Statistical Analysis	Dichotomous Independent Variable								
Results Statement	Sites that have landfill gas collection systems are approximately 4.7 times more likely to be privately owned than sites without landfill gas collection systems.								

Site Characteristic (Independent Variable)	Landfill Size (Permitted Disposal Area) Value and Number of Landfills Continuous																				
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)																				
	Box-and-Whisker Plot Owner Type Category by Permitted Disposal Area <p>The box-and-whisker plot displays the distribution of permitted disposal area in acres for two owner types: Private and Public. The y-axis is on a logarithmic scale from 1 to 1000. The Private group (blue) has a median around 150 acres, with the interquartile range (IQR) between approximately 80 and 400 acres. The Public group (red) has a median around 50 acres, with the IQR between approximately 40 and 250 acres. The Public group also shows two outliers near 1 acre.</p> <table><caption>Approximate Data from Box-and-Whisker Plot</caption><tr><th>Owner Type</th><th>Min</th><th>Q1</th><th>Median</th><th>Q3</th><th>Max</th><th>Outliers</th></tr><tr><td>Private</td><td>50</td><td>80</td><td>150</td><td>400</td><td>1500</td><td>None</td></tr><tr><td>Public</td><td>10</td><td>40</td><td>50</td><td>250</td><td>2000</td><td>~1, ~1.5</td></tr></table>	Owner Type	Min	Q1	Median	Q3	Max	Outliers	Private	50	80	150	400	1500	None	Public	10	40	50	250	2000
Owner Type	Min	Q1	Median	Q3	Max	Outliers															
Private	50	80	150	400	1500	None															
Public	10	40	50	250	2000	~1, ~1.5															
Variable Type for Statistical Analysis	Continuous																				
Results Statement	The permitted landfill area is statistically different (in this case, greater) for privately owned sites.																				

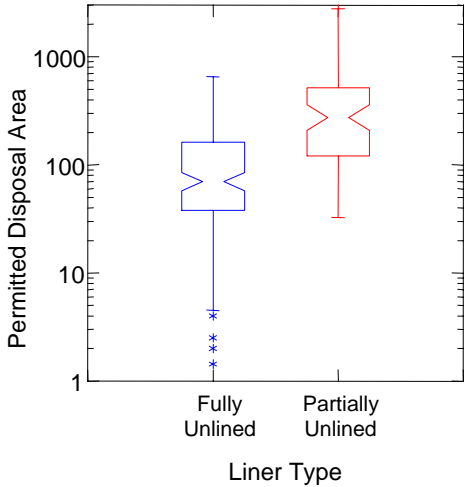
Site Characteristic (Independent Variable)	<div>Liner Type (Whole Site)</div> <div>Value and Number of Landfills</div> <div>Completely Subtitle* D or Subtitle D Alternative: 4</div> <div>Fully Lined – Partially Non-Subtitle D or Non-Subtitle D Alternative: 12</div> <div>Partially Unlined: 70</div> <div>Fully Unlined: 138</div> <div>*Also referred to as “Sub-D.”</div>														
Analysis of Independence	Dependent Variable: Owner Type (Binary Values: “Private” or “Public”)														
	<div>Number of Sites in Each Owner Type Category by Liner Type</div> <div><table><thead><tr><th>Liner Type</th><th>Private</th><th>Public</th></tr></thead><tbody><tr><td>Fully Lined Sub-D or Sub-D Alternative</td><td>4</td><td>0</td></tr><tr><td>Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative</td><td>4</td><td>8</td></tr><tr><td>Fully Unlined</td><td>19</td><td>119</td></tr><tr><td>Partially Unlined</td><td>29</td><td>41</td></tr></tbody></table></div>	Liner Type	Private	Public	Fully Lined Sub-D or Sub-D Alternative	4	0	Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative	4	8	Fully Unlined	19	119	Partially Unlined	29
Liner Type	Private	Public													
Fully Lined Sub-D or Sub-D Alternative	4	0													
Fully Lined, Partially Non-Sub-D or Non-Sub-D Alternative	4	8													
Fully Unlined	19	119													
Partially Unlined	29	41													
Variable Type for Statistical Analysis	Categorical Independent Variable														
Results Statement	Completely Subtitle D or Subtitle D-alternative sites are approximately 25.1 times more likely to be privately owned than fully unlined sites, and partially unlined sites are approximately 4.5 times more likely to be privately owned than fully unlined sites.														

Appendix C-2

Analysis of Independence—Liner Type (Whole Site)

As noted in Section 4.9.2, partially unlined sites appear to be more likely to be in non-compliance with the respective environmental standards, whereas fully unlined sites do not exhibit such correlation. One suggested explanation for this outcome is that partially unlined sites tend to be large and relatively complex, thereby increasing the likelihood of non-compliance with certain standards. In the examples discussed in Section 4.9.2, non-compliance appears to be associated with larger sites, as defined by the variable *Permit Area*.

An analysis of possible dependence between *Liner Type* and *Permit Area* was conducted, looking specifically at the difference between partially unlined and fully unlined sites. The results, included in this appendix, provide some support to the hypothesis that landfill size may influence whether certain liner types are more or less likely to be in non-compliance.

Site Characteristic (Independent Variable)	Liner Type (Whole Site) Value and Number of Landfills Partially Unlined: 70 Fully Unlined: 138
Analysis of Independence	Dependent Variable: Liner Type (Binary Values: Fully Unlined, Partially Unlined)
	Box –Whisker Plot of Permitted Disposal Area By Liner Type (Whole Site) 
Variable Type for Statistical Analysis	Continuous Independent Variable
Results Statement	Based on the available data, the permitted landfill area for Partially Unlined sites is statistically different (in this case, greater) than Fully Unlined sites.

Appendix D

Additional Analyses—Two-Factor Landfill Site Characteristics Census

Number and percentage of whole sites designated in the database as Rural or Non-Rural, for each independent variable category. See Section 5.2.1 for discussion.

Site Characteristic	Social Setting	Number of Sites	Independent Variable Category	Number of Sites in Independent Variable Category	Percentage Within Independent Variable Category
Owner Type	Rural	139	Private	22	39.3
			Public	117	69.6
	Non-Rural	85	Private	34	60.7
			Public	51	30.4

Average Annual Precipitation	Rural	139	>= 14 in.	58	49.6
			< 14 in.	81	75.7
	Non-Rural	85	>= 14 in.	59	50.4
			< 14 in.	26	24.3

Liner Type	Rural	139	Unlined	106	76.8
			Lined	33	38.4
	Non-Rural	85	Unlined	32	23.2
			Lined	53	61.6

Physical Setting	Rural	110	Desert	50	86.2
			Inland	60	50.4
	Non-Rural	67	Desert	8	13.8
			Inland	59	49.6

Site Characteristic	Social Setting	Number of Sites	Independent Variable Category	Number of Sites in Independent Variable Category	Percentage Within Independent Variable Category
Minimum Depth to Underlying Groundwater	Rural	139	>= 34.5	77	68.8
			<34.5	62	55.4
	Non-Rural	85	>= 34.5	35	31.3
			<34.5	50	44.6

Landfill Gas Collection System	Rural	139	Yes	37	39.4
			No	102	78.5
	Non-Rural	85	Yes	57	60.6
			No	28	21.5

Landfill Size (Permitted Disposal Area)	Rural	139	>= 122 acres	49	43.4
			< 122 acres	89	80.9
	Non-Rural	85	>= 122 acres	64	56.6
			< 122 acres	21	19.1

Landfill Age	Rural	139	>= 35 years	57	50.4
			< 35 years	82	73.9
	Non-Rural	85	>= 35 years	56	49.6
			< 35 years	29	26.1